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OLD AND NEW.

THE rates of industrial progression in the Old and New Worlds have ever afforded interesting subjects for comparison. At the meeting of the British Association, Prof. Ayrton in his lecture on the transmission of power did not fail to compare the lethargy of Englishmen with the go-ahead nature of the American, and at all times and in all seasons when electrical progress is the theme, we find the American lauded, while we poor Britishers suffer, of course, by a comparison which sometimes we may be tempted to regard as odious.

Once more Prof. Forbes in his paper on "Electric lighting in America" struck the keynote of this old, old song. He referred to the ability of the Americans to grapple with the requirements of the community, he praised their industrial skill and lauded their highly specialised methods of production. Their electrical apparatus generally was of a kind inferior to ours, but along with its inferiority there always went an earnest desire on the part of the user to make it work its best if it would work at all. In fact, the reports we are constantly hearing from the other side of the Atlantic seem to show that our old proverb, "Necessity is the mother of invention," has there become inverted, and in that go-ahead Republic reads "Invention is the mother of necessity." It is a matter of every-day experience that in the effort to satisfy wants more wants are created, and the statement has been recognised as an axiom in economic science. But mankind generally take the easiest way of satisfying their wants, and the highest type of humanity is the type which, having a multiplicity of wants, satisfies them with least effort. If we invent to satisfy a want which has already become manifest we do well, but if we invent something which developes a want whose existence is scarcely suspected we do better. The Americans seem to us to follow out the latter course, hence our remark that they have done their best to invert the time-honoured proverb which supposes that necessity alone gives birth to invention.

The rapid development of the electrical industry in America Prof. Forbes attributes to technical education among the monied classes, but we are far from agreeing with him on this point. As a matter of fact, capital is always forthcoming here when the capitalist sees a decent chance of a return for it. There is no lack of capital; it is the market for electricity that is wanting, and in the deeply rooted antagonism of the Britisher to change of any sort lies the real hindrance to progress with us. America is a new country; its societies are developing at an enormous rate, accompanied by an industrial activity almost incredible. In this young industrial organism change is rapid and easy, but how is it with us? Ours was an old country when America's industrial birth took place. We have interests of extraordinary complexity everywhere at stake, and each of these have to be considered when a new departure is projected. As a result change with us can only take place slowly, and we can apply no panacea for changing the character of a people, or for eradicating the inheritance of ages.

Technical education is utterly powerless to effect a change of the kind desired. The Professor admits that we have here the inventive skill, and, we might add, that we have the inventions ready to hand. We have certainly everything in the way of apparatus that the Americans have. It is possible we may not possess a knowledge so complete as theirs regarding the equipment of central stations, but this is only in consequence of our poverty of experience in such undertakings, and the demand for a few stations would soon put us on a par with them in this respect. We have technologists with the ability to take charge of large plants as well as engineers able to lay them down. How then will technical education help us? If education of any kind is required it is the education of the public to appreciate and employ the new illuminant, and technical education is not of the sort to attain this end. If every householder in Great Britain were capable of designing a dynamo, or wiring his own house, we question whether lighting would make one whit more progress. What we have to do is to show the consumer that, all things considered, it is better to have the electric light; and having once established this fact beyond dispute, and created a want to be supplied, let us show the capitalist that it will pay to supply the want, when there will be found no lack of means to do so. In all the new towns in America they have the electric light. These towns discovered a want, and it may be that in places where money was made easily the inhabitants, heedless of the cost, were often moved by the feelings which in early days prompted the Australian miners to light their pipes with bank notes; but to us that matters not. Whether their wants were due to a craving for something new we do not stay to enquire, the point is that a general want existed, and we in Britain have only just succeeded in creating a similar want. Whether the public were induced to reject electric illumination because it could not compete with gas is outside the question. The only fact we are aware of is that on the terms on which it was offered generally it was not wanted, and hence its progress has been limited.

It may be said that our business men are not quite so smart here as in America, and there may be some truth in the statement. At the same time, American smartness is not the kind of thing which we should like to brag about, and for real honest work we are accustomed to think we are not behindhand. We have not the same facilities for making a market, and the area of our efforts is necessarily limited. To compare the lighting to be done in America with the lighting to be done in Great Britain is a manifest absurdity. If every electrical factory in our land were at once increased to ten times its present size the possible production would be then but a small fraction of the production in

American factories. Though production is cheapened by working on a large scale, let us bear in mind that American factories are the result of the demands of the American public for the electric light. Let us create a demand, and the factories to supply it will soon arise.

It is not likely that by production on a large scale our manufactures will be cheapened so as to influence to any great extent the demand, although in the matter of incandescence lamps there is room for considerable reduction in price. Lamp renewals form a large item in our maintenance account, and a cheaper lamp would be at the present moment a real gain. Though naturally there would go on a continuous reaction between prices and demand resulting in a step by step reduction in the former and a step by step increase in the latter. we cannot be content with such an increase in demand as would be due only to the cheapening of production. We have to show the public, above all things, that the electric light pays ; we have to demonstrate, demonstrate, demonstrate until there is no escape from the hard logic of facts. We have to oust our rival illuminants from the field, if possible ; to remove all hindrances to progress ; and to stimulate and develop a want begun to be felt. When we have created the demand there will be no difficulty about the supply. Just as fast as it is required capital will be forthcoming, and without doubt factories will spring up just as fast as work is created for them.

THE proceedings at the meeting of the British Association were considerably enlivened by the important discussion on lightning conductors, held conjointly by sections A and G. The exponents of the rival hypotheses are far from agreeing, and we have not by any means heard the last word on the subject. We have trusted too long in a security which it appears is but fancied. We imagined we knew all about the behaviour of lightning, or at least knew enough to prevent, by erecting lightning rods, its misbehaviour ; but in the light of Prof. Lodge's remarks, we shall have to remodel our ideas and recommence our studies. It is not the time to express any opinion upon the general question, as many more experiments will have to be made before a satisfactory conclusion is reached. The arguments on both sides were well put forward, but the chief interest centres at present in the doctrines of Prof. Lodge, who has made most careful investigations of the behaviour of sudden rushes of electricity. Prof. Lodge says that the electricity in such cases keeps wholly to the outside surface of the conductor, and that the obstruction met with has next to nothing to do with the specific resistance or magnetic properties of the material. His experiments lead him to the conclusion that iron is as good as copper for lightning conductors, and that the protective influence of lightning conductors is exaggerated. Mr. Preece, who stuck to the old doctrines, spoke well for his side, and at present the contest may fairly be considered a drawn battle.

BUT when Mr. Preece starts on the subject of definitions or units, we open our ears and our eyes, prepared for someting new. "It is incredible," said Mr. Preece in his presidental address, "that having utilised this great power of nature to such a wide and general extent, we should be still in a state of mental fog as to the answer to be given to the simple question—What is electricity ?" Mr. Preece does not answer the simple question, though he remarks that the engineer regards electricity as a form of energy. Whatever electricity may be, it is not energy, and we fail altogether to see what Mr. Preece, in his further remarks, is driving at. We venture to think that Mr. Preece has libelled the engineer, for maligned deservedly though he sometimes is, he is seldom foolish enough to regard electricity as a form of energy. Generally speaking the engineer regards electricity as some kind of matter, and talks of it as such. He does not know its exact character, but he knows that its quantity into distance gives energy in much the same way as quantity of water into distance gives energy. Mr. Preece would scarcely say that water, or wind, or steam is a form of energy, though we know that water in motion, air in motion, and steam in motion are all forms of energy just like electricity in motion. For ourselves, we have never experienced the necessity for an exact definition of electricity, and we are inclined to believe that Mr. Preece is fighting a bogey of his own invention. To physicists, the term electricity is but the comprehensive title for a somewhat extensive group of facts. Electricity may be matter, or it may be motion, but it certainly is not energy, and we think the practical engineer already knows this, Mr. Preece notwithstanding.

THE terms *Kine*, *Bole* and *Barad*, suggested by the Committee on Mechanical Nomenclature, are simply an abomination, and wholly unnecessary. We are inclined when we meet such suggestions to ask when this insane craze for new terms is likely to cease, or whether the Brit. Ass. is ever likely to become sensible. In what respect is the expression "a velocity of one kine," better than "a velocity of one centimetre per second ;" or the phrase "a force of one barad" superior to "a force of one dyne per centimetre." It is absolutely certain that the latter is more expressive than the former, while its use involves no effort of memory to realise the meaning conveyed.

IF these terms are adopted, we may look for other suggestions at future meetings. Engineers will learn how utterly lost they have been in speaking of a force of "one pound per square inch," and will in future talk of a force of a *Bram*, named after the president. They will cease to compute velocities in "feet per minute," and talk instead of a velocity of so many *Preeces* in honour of the president of Section G. To the electricians might be given *Fitz*, as the expression for one C.G.S. line of force per square centimetre. This would be named after the president of Section A., and thereafter we would speak of a field of 20,000 *Fitz*. There is no limit to this sort of thing, and we will promise to find a brand new name for anything and everything if desired. For terms apply at 22, Paternoster Row.

FOR some reason or other this is called the silly season, and as if there were not sufficient evidence of the commodity which gives the season its name in the doings of the B.A., one of our contemporaries is seriously discussing the possibility of tying knots in space of four dimensions. We have no desire to limit the enterprise of our neighbours, but we have always found space of three dimensions sufficiently large for our requirements and the phenomena exhibited in such space comprehensive enough for our study. We are of opinion that journalists who attempt to tie knots in four-dimensioned space stand a very good chance of

producing at the same time a permanent crank in their own minds. There is no reason, as Sir William Hamilton remarks, for infering a certain fact to be impossible merely from our inability to conceive its possibility, but until the capacity to *think* space of four dimensions is bestowed upon us, the attempt to condition the phenomena occurring in such space strikes us as being, to use an Americanism, a trifle too previous. Let our contemporary moderate its ambition; there is plenty of work to be done yet in three-dimensioned space.

PROFESSOR FORBES in his paper read before the British Association laid great stress upon the interchangeable character of the Westinghouse apparatus. There can be no doubt that interchangeability of parts is a most desirable thing to aim at, but it has also its weakness. Once decide on a type, specialise tools for its manufacture, and change becomes a very serious matter, or next to impossible; for improvements in the apparatus become more difficult to make in proportion as the tools are more specialised. The Westinghouse Company started with all the experience of other workers and were therefore in the position to decide at once upon a type which would be very efficient and require little change as time went on. But one hesitates to think what stereotyping the earlier forms by introducing specialised plant would have meant.

In another place will be found a paper read by Sir William Thomson at the British Association on "Five Applications of Fourier's Law of Diffusion," which is of a very interesting character. We remember that many years ago Sir William, by an application of Fourier's theory to the rate at which the earth was cooling, calculated the limits of the period at which it began to solidify at somewhere between a hundred millions and two hundred millions of years ago. The remarkable thing about the theory of diffusion, as applied to mixtures, is that by it we can tell the condition of a mixture at any future period; but if, having the mixture in a particular state, we attempt to write its past history, we come to a point where, as Sir W. Thomson showed, the expressions no longer give a correct indication of what occurred. Sir William shows, for instance, the condition of a mixture of sugar and water in 17×10^5 seconds after the water has been poured on the sugar; but if we take the mixture, say at 10×10^5 seconds after pouring, and attempt to find by the equations its condition in the past, we discover the formulæ are workable only for a certain period. To use the language of the late Prof. Clifford, they begin to talk nonsense when there takes place an event of which they, as equations for diffusion, can take no notice, namely, the pouring in of the water. Fourier's theory has endless applications, and the study of these is full of scientific interest. We notice that as the potter by his art dignifies common clay, so the philosopher invests with scientific importance the commonest things, and that in the hands of Sir W. Thomson, the homely "toddy ladle" becomes a philosophical instrument. We have often employed this apparatus, but consider that Sir William's remarks justifies our further practice with it. We may have thought of Fourier when mixing our sugar and water, but fear the added whiskey tends to make a solution of diffusion problems less easy. Invariably we have had to assist the diffusion by vigorous stirring, as 17×10^5 seconds is too long for us to wait notwithstanding the interesting character of the observations.

The following utterance from a commissioner of patents marks a new departure in the method of dealing with applications for patents in the United States:—"Even if novelty were admitted, it must be held that a patent must be refused, at least until the applicant practically demonstrates the operativeness of the device. The patent system was never designed to protect the chimerical schemes of visionaries. Invention consists in more than the work of the imagination. This applicant has only carried his conception up to the point where invention must begin."

WE notice that the Americans are about to connect their life-saving stations on the Long Island coast by telephone. How long must we wait for the often talked of establishment of a telegraph or telephone system which shall connect up our coastguard and lifeboat stations?

WE are curious to learn the exact position of the Maxim-Weston Company financially. At this juncture it is no easy task to gain the desired information. The *Financial News* one day this week printed what purported to be extracts from a circular recently issued by the new board of directors to the shareholders. But they were followed next day by a repudiation of the figures given, from Messrs. Boyce & Ramsay, the accountants, and by a letter from Mr. Hugh Watt, impugning the accuracy of the statements made, in so far as they related to himself, and intimating that a law suit is pending respecting the questions upon which the company and he are at issue. Upon this we endeavoured to get a correct copy of the directors' circular, but were met with the reply that the matter was a private one between the shareholders and the board, and the directors did not wish their circular to be published. If the circular really contained the statements which were published in the *Financial News*, it would of itself, we should think, form the ground of an action, for accusations of conduct approaching dangerously near to fraud are made. Some shareholder who has received the circular may possibly deem the matter of sufficient public interest to forward his copy to us, so that we may be enabled to accurately reproduce it for the benefit of our readers.

EVERY week now brings a fresh list of towns and districts which have resolved to adopt the electric light for street illumination or are considering the advisability of adopting it. Yet the City of London lags behind. But this cannot be for long. Indeed, judging from the utterances of the chairman of the Streets Committee of the Commission of Sewers, there is now every intention to resort to electricity, and the prolonged delay is caused only by the desire of the commissioners to deal thoroughly and effectually with the subject. Fortunately there will be no Mr. Hugh Watt to interfere, with distracting proposals, just when negotiations seem complete, so we may at an earlier date than is generally supposed find the streets of the metropolis worthily and adequately lighted. Outside the city boundaries, too, the subject of the electric light has been receiving attention. The Strand District Board of Works has just had the question of lighting the Strand by electricity under consideration, but in the reports which have reached us it does not seem quite clear whether its sanction has merely been given to the running of cables for private lighting, or whether it has committed itself to the lighting of the Strand itself by electricity.

ELECTROLYSIS OF TIN SALTS.

By ALEXANDER WATT.

(*Continued from page* 272.)

5. *Acetate of Tin by Electrolysis.*—A quantity of acetic acid, moderately diluted, was put into a glass vessel, and in this was suspended a tin anode and brass cathode, connected to two Daniells in series. In about a quarter of an hour the brass plate received a film of tin, at first white, but gradually assuming a dark-grey colour. A single cell was next tried, when the deposit became whiter; there was a considerable evolution of hydrogen, the bubbles of which were of large size, before the plate became coated with tin, but as soon as the plate was covered with the deposited metal, the bubbles became considerably reduced in size, while the gas also escaped more freely from the tinned surface than from the brass. Indeed, the gas bubbles set free upon the naked brass rested for some length of time, until they attained the size of a small pea before rising to the surface of the liquor, whereas from the tinned surface they quickly escaped in small globules.

6. *Acetates of Tin and Soda.*—Sixty grains of acetate of soda crystals were added to about 10 ounces of the foregoing solution, and the mixture stirred until they were dissolved. A freshly-prepared brass plate was then immersed, which slowly received a white and somewhat bright film of tin; this, however, gradually became dull and of a dark colour. There was much gas given off at the cathode, which in about fifteen minutes formed a thick, white froth on the surface of the liquid. The current from a single Daniell was used, and on examining the anode after a series of trials in this bath, the immersed surface was found to be very bright and clean.

7. *Nitromuriate of Tin* (*Dyers' Spirit of Tin.*)—A solution of this salt was prepared as follows:—Sixty grains of salammoniac were dissolved in 1 ounce of nitric acid, and to this mixture was added, in small quantities at a time, 60 grains of powdered tin. When the tin was all dissolved, the solution was gently evaporated, until a nearly solid mass was obtained, when the vessel was set aside until cold. The product, which formed a transparent, gummy mass, was next dissolved in about 10 ounces of cold water, and after filtration was subjected to electrolysis with the current from two Daniells in series. In this solution a brass plate received a dull but white film of tin—on the surface facing the anode only—after a few seconds' immersion. There was not much gas liberated at the cathode, but it was found that the anode became coated with a yellowish deposit, which, after a few minutes, assumed considerable thickness, while the solution acquired a yellow colour, and finally became decomposed, when it ceased to yield a deposit of metallic tin.

8. *Sodio-bichloride of Tin.*—Half a fluid ounce of the concentrated solution of bichloride of tin was added to ten ounces (half-a-pint) of water. Sixty grains of chloride of sodium were then added and dissolved into the liquid, with stirring. The current from one Daniell cell was used, and a brass plate, as before, for the cathode. Immedately after immersion the plate received a good white deposit of tin, and deposition proceeded with perfect uniformity during a long immersion. When the plate was withdrawn the coating was found to be reguline, and there was no appearance whatever of sponginess at any part of the plate, while the anode was perfectly clean. A plate of steel was next put into the bath, and this became at once coated with tin, and at the end of half-an-hour or so received a fairly good deposit of the metal, which adhered well to the steel surface. It is probable that a solution of this composition, if prepared with care, might be found useful as a depositing bath, and since the anode becomes freely dissolved during the electrolysis, the solution would not be liable to vary much in its metallic strength. Another advantage which this solution presents is that only a very small anode surface—about one-fourth that of the cathode—is required. A solution that will coat brass and steel satisfactorily would also be applicable to copper and iron, and since a solution of this character is much needed, it may be worth trying on a larger scale than was necessary for the purposes of the foregoing experiment.

9. *Potassio-bichloride of Tin.*—A dilute solution of the bichloride was first prepared, as before, and in ten ounces of the liquid was dissolved sixty grains of chloride of potassium. The current from a single Daniell was used, and the immersed anode surface was about one-fourth that of the negative electrode, under which conditions, the latter, a clean brass plate, became coated with a pearly-white film of tin immediately after immersion; although the deposit somewhat darkened in colour after a time there was no tendency to sponginess—or semi-crystalline character—while the deposited metal was firmly adherent. It may be said that there was little or no perceptible difference between the behaviour of this solution and the preceding, but in some respects a preference might be given to the latter—if either could be found practically available.

10. *Ammonio-bichloride of Tin.*—Half-a-pint of solution of bichloride of tin was prepared as before (Exp. 8) and to this was added 60 grains of sal ammoniac, in fine powder, and the liquid stirred until the latter was dissolved. The same current and anode surface were employed, when a clean brass plate became coated with a white film of tin immediately after immersion. There was but little evolution of hydrogen, and the deposition, as before, proceeded with perfect uniformity, there being no evidence of spongy metal during a prolonged immersion of the cathode. Although the results obtained from this bath were of a satisfactory character, so far as the metal having no tendency to sponginess, of the three solutions last treated I am still disposed to give the preference to the sodio-bichloride, that is assuming that either of them could be made available for the practical deposition of tin for useful purposes in the arts, which I am disposed to think is not beyond the region of probability.

11. *Tin Chloride and Pyrophosphate of Soda.*—A moderately strong solution of pyrophosphate of soda was first prepared, to which was added gradually a solution of protochloride of tin, allowing the precipitate at first formed to redissolve before making further additions, the chloride solution being cautiously added until the liquid became nearly saturated. The solution was then set aside for an hour or so, and the clear liquor then decanted for use. The solution was then electrolysed with the current from two Daniell cells, when a clean brass plate promptly received a white film of tin, which, however, soon turned grey, from the formation of spongy metal. The bath was next diluted with water, a little at a time, until the deposit retained its whiteness during a long immersion of the plate. This solution makes a very tolerable tinning bath, but since the anode dissolves but slowly, constant additions of the respective salts in a concentrated form are necessary to keep up the proper metallic strength of the bath. The anode surface should also be much greater than that of the articles to be tinned in this solution.

12. *Sulphate of Tin.*—A solution of this salt was prepared by dissolving recently-precipitated hydrate of protoxide of tin in hot dilute sulphuric acid. The solution was afterwards diluted with about twelve volumes of water, and electrolysed with the current from a single Daniell, when a dull white deposit of tin at once appeared upon a brass cathode. After a short immersion the lower portion of the plate exhibited minute crystals of tin, which almost immediately after spread over its entire surface, and in a few minutes the crystals extended considerably, their growth being almost, if not actually, visible to the eye. The structure of the crystals from the sulphate solution was greatly different from those to which I called attention in the last paper, being of an arborescent or tree-like character; indeed, much like a leafless tree in winter. Some of these crystals were afterwards formed upon a glass plate, as described in the former article, but as they had a

tendency to grow vertically as well as horizontally, they were not so well suited to print from by the photographic process as the chloride crystals; it is probable, however, that I may be able to overcome this little difficulty, and I hope to give an illustration of the sulphate crystals in the next paper, which I am anxious to do, as they differ greatly from the chloride crystals in structure. Being desirous of ascertaining whether further dilutions of the sulphate solution would tend to destroy its tendency to yield crystalline deposits, the bath was next weakened by the addition of an equal volume of water, and a fresh brass plate immersed, which promptly became coated with a white film of tin, and continued to retain its reguline character for some minutes, when the deposit gradually assumed the grey and spongy form.

From this and former results it appears that when solutions of tin, which in a more or less concentrated condition yield large crystalline deposits, the same solutions, when considerably diluted, cause the metal to assume a more minute form of crystallisation, the agglomerated crystals taking the form of a spongy, but glittering, mass. It was interesting to observe that the tin anode, after being used for some time in the several solutions named, acquired the peculiar crystalline appearance known as *moirée metallique*, and that it retained this character throughout a long series of experiments, although it had been considerably reduced in substance by the solvent action of the various electrolytes employed.

13. *Sulphates of Tin and Ammonia.*—A moderate quantity of sulphate of ammonia was added to the preceding solution and dissolved into the liquid with stirring. The bath was then tried with the current from a single Daniell, when a fine white film of tin was at first obtained upon a brass plate, but after a few minutes' immersion a spongy deposit appeared at the edges and corners of the plate. The liquid was now again further diluted with water, and a very small portion of the anode only allowed to dip into the fluid, under which conditions a newly-prepared plate at once received a white coating of tin, and continued to do so without the appearance of spongy metal during the first five minutes, at the end of which time the corners of the plate again became coated with non-adherent and spongy tin. There was no gas evolved at the electrodes. A further dilution was next tried, at which point the solution had become exceedingly attenuated, with a view to obtain, if possible, a metallic deposit, free from sponginess—a reguline deposit, in fact. In the very dilute bath which resulted from the foregoing heavy dilutions, a brass plate now received a very white film, of a pearly hue, and for some time but little change was observable; eventually, however, the inevitable spongy deposit appeared at the bottom of the plate, when the experiment was terminated.

14. *Sulphate of Tin by Electrolysis.*—A dilute solution of sulphuric acid was first prepared, and in this was immersed a tin anode, connected with two Daniell cells in series, a clean brass plate, as before, being used as the cathode. In this solution, under the conditions given, the brass plate became thickly coated with spongy tin in less than five minutes, while a portion of the same deposit remained suspended from the bottom of the plate in the form of a thick spongy mass, which rapidly increased in bulk. The plate was now withdrawn, and the solution considerably diluted with water, a fresh plate being then immersed, which at once became coated with a white film of reguline metal; this character was not sustained, however, for shortly after the white layer became covered with a loose dark grey deposit of spongy tin. Further dilutions of the liquid were tried, but, as in all the previous trials with the sulphate solution, the deposit invariably assumed the semi-crystalline or spongy state soon after the first white film had been deposited.

15. *Persulphate of Tin.*—A solution of this salt was formed by dissolving moist hydrated peroxide of tin in hot dilute sulphuric acid, the concentrated solution being afterwards diluted with about eight times its bulk of water, and filtered. In the solution thus prepared, and with the current from one Daniell cell, a brass plate quickly became coated with white tin, the film, however, gradually becoming rather dark in colour after a short immersion. A good deal of gas was liberated at the cathode, and in a few minutes the deposit became of a dark grey colour, this *secondary* film, as I may perhaps term it, being, as in all previous cases, non-adherent, while the first, or *primary* film, possessed all the characteristics of good reguline metal, from which the former could be removed by rubbing with the finger.

16. *Sulphates of Tin and Soda.*—A small quantity of a strong solution of sulphate of soda was added to a solution of tin sulphate, and the resulting liquid electrolysed with the current from a single Daniell cell, when a white deposit of tin was at once obtained; this, however, soon became dark coloured, and in a few minutes the plate was covered with a nearly black deposit of spongy tin. The solution was next weakened by the addition of an equal volume of water, when, on immersing a fresh plate, a pearly white film formed upon its surface, and retained this character for some minutes, when the spongy deposit began gradually to form and appeared in minute but separate lumps all over the plate, leaving the intermediate surfaces speckled, as it were, with the first white film, thus giving the plate a very singular appearance.

17. *Sulphates of Tin and Magnesia.*—Having frequently observed that an addition of sulphate of magnesia sometimes improved the character of metallic deposits from acid solutions, I added a small quantity of the magnesium salt to a solution of sulphate of tin, when I found that the deposits of the latter metal retained a reguline condition for a somewhat longer period than in some of the former instances, but the advantage was not long sustained, however, for the metal eventually assumed the spongy form; even when the solution was considerably diluted, the same result invariably presented itself, namely, the first layer of the metal after a certain time became coated with the semi-crystalline deposit.

18. *Sulphates of Tin and Potassa.*—A solution of the mixed salts, in varying proportions, yielded results very similar to those above mentioned, and it was found to be practically impossible to keep the deposit in a reguline condition after the first film was obtained, unless the cathode was kept in constant motion, in which case the deposit retained its homogeneous character so long as the agitation was kept up.

19. *Chloride of Tin and Bitartrate of Potassa.*—Sixty grains of cream of tartar were added to a moderately strong solution of protochloride of tin (7½ grains of the salt to each ounce of water) and dissolved into the liquor. The solution was then tried with the current from one Daniell, when a brass plate at once received a fine white deposit of tin, which retained its uniformly white colour for several minutes, after which the plate gradually became dark in colour, the spongy deposit appearing first at the edges and finally all over the plate. The solution was then diluted with about half its volume of water, and a new plate immersed, which, as before, received a brilliantly white film of tin, and continued to do so for several minutes, when the coating again darkened as before, from the formation of spongy metal, and at the end of about twenty minutes or so the spongy coating appeared all over the plate, but more especially so at the lower surface, where it thickened considerably, and eventually dropped off the plate in lumps. The solution was again diluted, and the experiment repeated, but although the deposition was exceedingly slow, a very small anode surface being immersed in the bath, the pearly white deposit at first obtained, as in the former results, was finally succeeded by the deposition of the metal in the spongy form.

(*To be continued.*)

Bedford and the Electric Light.—Pending the consideration by the Bedford Town Council of the future lighting of the borough, a company has been formed, called the Bedford Electric Light Company, with a capital of £15,000 in £1 shares.

JOINTS IN UNDERGROUND WIRES.

THE question of placing electric wires—whether used for lighting, telegraphic or telephonic purposes—underground has for some time past assumed an important phase in the construction of electric lines in the United States, and at the meeting of electrical societies held lately and for some time past, papers of great interest upon this subject have been read. Underground wires have for many years been a matter of the greatest difficulty in the States, especially as regards their durability, and of late years have not been usually attempted unless no other means were available. However, as is well known, the matter has become now one of a compulsory character, and frequent accounts come to hand of the various new systems of underground work constructed.

For telegraphic work in this country we continue the system originally introduced, but which experience has vastly improved in matters of detail, but for electric light purposes no system of uniformity has yet been arrived at. But it is not on these points we would wish to draw attention, but to a minor detail, though still one of the greatest importance. Some time since an examination of numerous joints and splices in heavy main cables used for electric lighting, showed the writer that there was very great diversity in the character of the joints made, whilst in the manner of making them there was still a greater diversity as to the quality of the work. Experience with the manner in which various installations were carried out, proved that there was no general system in use in this country for making joints in electric light wires, and especially in heavy cables.

The form and construction of cables, the methods adopted in insulating and protecting are points which have been frequently brought forward and discussed, but as to the best method of joining cables together but little information can be obtained except by observation during the progress of any work. Much has been said as to the bad character of this class of work, but little has been done to direct attention to the faults which exist or to the manner in which they could be improved. Even the question of soldering is a "vexed" one. It is well known that jointing, or rather imperfect jointing, has been the cause of many a faulty installation, and contractors are frequently much exercised as to obtaining thoroughly competent and reliable men to do the work. It is unfortunately the case that these two qualities do not always go together. Jointing, it must be acknowledged, is not such an easy matter as it may appear to be, and it is not every one who can readily acquire the art of soldering.

Having examined a large number of joints of various kinds, and frequently experimented in making joints in heavy cables, the writer was led to enquire whether there was any definite system in use in the United States, where from the enormous amount of experience gained in so great an extension of the electric light system it was considered that possibly some more uniform plan was adopted. As regards jointing and other details of construction the papers read on the class of cables used were singularly deficient in information; the writer therefore placed himself in communication with his friend Mr. W. J. Johnston, the courteous and well-known publisher of the *Electrical World* of New York, with the view of obtaining some data on this point. Mr. Johnston has been kind enough to forward some information, the result of some enquiries made by a leading member of his staff, which it is felt certain will be found of interest by the readers of the REVIEW. Whilst the enquiry was made as to joints in electric light cables generally, the replies and information supplied are directed to underground electric circuits only. The following is a copy of the report forwarded:—

"The character of underground electric circuits varies, of course, with the nature of the currents to be carried by the wires, but there are some details practised by various companies which are sufficiently distinct from older, well-known methods, to require more definite explanation.

"Beginning with the underground lines of the Commercial Cable Company in this city (New York). These consist, for the most part, of lead-enclosed cables, in which the joints are made as follows:—The lead is cut off from the insulation a few inches each side of the end, and the sleeve slid over one of the ends. The wire is then bared for about 3 inches, and a regulation telegraph lineman's joint is made and soldered. The joint is then covered with insulating tape; the lead sleeve above mentioned is then slipped over the ends, so as to cover the joint, and the ends of the sleeve are soldered to the body of the lead cable. Through a hole with which the sleeve is provided, hot insulating material is poured till the air bubbles cease to rise. When completely filled, a cap or cover is placed over the hole, and soldered to the rest of the lead cable. The work is said to be very simple, and can be rapidly performed.

"In similar lead-covered cables carrying large sizes of wire, such as for incandescent lighting, the joint made is a scarf joint, similar to the well-known ocean cable joint, but the rest of the proceeding is as just mentioned.

"In the cables used by the Western Union Company the joints are twisted and not soldered; they are wrapped with India-rubber joint tape, and bunched, and kerite tape wound outside of that. Formerly a great many of the joints were made with the India-rubber of the joint vulcanised to that of the cable proper, but this is no longer practised. I am told that some of these cables which have been in iron pipes since 1876 did not work very well.

"The Telephone Company, which is at present putting down a large number of wires in this city, employs a peculiar method of jointing. The ends are bared, and over one of the wires there is slipped a length of what is here termed "hoop-skirt braiding," * that is, a hollow braid. They take the two ends to be jointed, place them side by side, so that the ends point in the same direction, and twist them together. The wire was then drawn out straight into line, and the twisted ends laid down flat against the wire in the direction of its length. The hollow braid is then slipped over the joint, and its end tied securely with twine. After all the joints in the cable have been made in this manner, they are thoroughly impregnated with hot paraffin, and wrapped around with lamp wick, and then given another bath of paraffin. The lead sleeve is then slipped over the combined joints, and the whole given a regulation plumber's wiped joint, but connected to the lead cover in which the cable is encased. These joints are only made in clear dry weather, as dampness is very detrimental, as is evident when paraffin is used as an insulating material.

"The joints in the Edison underground cable are made as follows:—The wires in the tube pass through hard rubber blocks at each end of the section of pipe, which is 20 feet in length. Each of these sections is connected by flexible joints; these consist of copper sockets, tinned, which are slipped over the ends of the copper wires and heated, and then thoroughly soldered and sweated together. The sockets, which connect corresponding sections, are connected by a short length of stranded cable. The ebonite blocks at the end of the tube are then scraped to remove any carbonised material, and cast iron boxes are placed around the joints and clamped together, and then filled with an insulating material consisting of an asphalt compound.

"These constitute the principal methods of jointing the underground work in this country."

In view of the increasing use of lead-covered cables for underground work, the above remarks relative to the manner of joints adopted in the States will undoubtedly prove interesting. Probably, however, some surprise will be felt that the Western Union Company prefer unsoldered joints. It has been frequently argued

* Called here "tubular braiding."

over here that a clean twisted joint unsoldered and well insulated is infinitely better than a bad soldered joint. But it may with perfect correctness be argued in reply that there is no reason why there should be any badly soldered joints. If such things are met with in ordinary construction work, it is simply a proof that a bad workman has been employed. In ordinary telegraph construction no man is allowed to make a joint in aerial wires until he has been proved to be a good jointer, and beyond that all joints are inspected by the foreman. It is because such simple means are not adopted in electric light work that so many complaints have arisen. Jointing and soldering have been so often considered as simple work that almost any wireman is supposed to be capable of doing it, but the more the experience gained on this question the firmer is the conviction that the greater is the care necessary to make a joint absolutely safe and permanent.

It would appear from the remarks given of the practice in the United States that the prevailing joint for heavy cases is a "scarf," similar in every respect to those usually formed in the conductor of an Atlantic cable. For similar purposes such a joint may be considered quite good enough, but the conditions under which the conductor of a cable passes is vastly different to that of an electric light conductor. In the first case the temperature is unaltered, whilst in the second it is subject to frequent changes, amounting to many degrees difference; under such circumstances of expansion and contraction a large amount of strain is thrown on such a joint, and the question arises will it continuously stand it. In the form of twisted or interlaced joint very largely adopted the mechanical strength is sufficient to stand any strain up to and equal to the breaking strain of the cable itself. The objections to this form of joint are its bulkiness, the extra time necessary to make one, and the special skill required. A little practice, however, soon overcomes these difficulties, the result being a joint both electrically and mechanically perfect. On the question of soldering, the necessary observations are postponed until a future occasion.

THE BRITISH ASSOCIATION.

FIVE APPLICATIONS OF FOURIER'S LAW OF DIFFUSION, ILLUSTRATED BY A DIAGRAM OF CURVES WITH ABSOLUTE NUMERICAL VALUES.

By Sir WILLIAM THOMSON.

(Section A.—Mathematical and Physical Science.)

Saturday, September 8th, 1888.

1. Motion of a viscous fluid.
2. Closed electric currents within a homogeneous conductor.*
3. Heat.
4. Substances in solution.
5. Electric potential in the conductor of a submarine cable.†

1. Fourier's now well-known analysis of what he calls the "linear motion of heat" is applicable to every case of diffusion in which the substance concerned is in the same condition at all points of any one plane parallel to a given plane. The differential equation of diffusion,* for the case of constant diffusivity κ, is—

$$\frac{dv}{dt} = \kappa \frac{d^2 v}{dx^2}$$

where v denotes the "*quality*" at time t and at distance x from a fixed plane of reference. This equation stated in words is as follows:—Rate of augmentation of the "*quality*" per unit of time is equal to the diffusivity multiplied into the rate of augmentation per unit of space of the "*quality*."

The meaning of the world "*quality*" here depends on the subject of the diffusion, which may be any one of the five cases referred to in the title above.

2. If the subject is motion of a viscous fluid, the "*quality*" is any one of three components of the velocity, relative to rectangular rectilineal co-ordinates. But in order that Fourier's diffusional law may be applicable we must either have the motion very slow, according to the special definition of slowness in Article xcvii.; or the motion must be such that the velocity is the same for all points in the same stream-line, and would continue to be steadily so if viscosity were annulled at any instant. This condition is satisfied in laminar flow, and more generally in every case in which the stream-lines are parallel straight lines. It is also satisfied in the still more general case of stream-lines, coaxial circles with velocity the same at all points at the same distance from the axis. Our present illustration, however, is confined to the case of laminar flow, to which Fourier's diffusional law for what he calls "linear motion" (as explained above in Section 1) is obviously applicable without any limitation to the greatness of the velocity in any part of the fluid considered (though with conceivably a reservation in respect to the question of stability).† In this case the "*quality*" is simply fluid velocity.

3. If the subject is electric current in a non-magnetic metal, with stream-lines parallel straight lines, the "*quality*" is simply current density, that is to say, strength of current per unit of area perpendicular to the current. The perfect mathematical‡ analogy between the electric motion thus defined, and the corresponding motion of a viscous fluid defined in Section 2 was accentuated by Mr. Oliver Heaviside in the *Electrician*, July 12th, 1884; and in the following words in the *Philosophical Magazine* for 1886, second half-year, p. 135: "Water in a round pipe is started from rest and set into a state of steady motion by the sudden and continued application of a steady longitudinal dragging or shearing force applied to *its boundary*. This analogue is useful because everyone is familiar with the setting of water in motion by friction on its boundary, transmitted inward by viscosity." Mr. Heaviside well calls this analogue "useful." It is, indeed, a very valuable analogy, not merely in respect to philosophical consideration of electricity, ether, and ponderable matter, but as facilitating many important estimates, particularly some relating to telephonic conductors and conductors for electric lighting on the "alternate current" system. In a short article to be included in volume iii. of my collected papers, which I hope will soon be published, I intend to describe a generalisation, with, as will be seen, a consequently essential modification of this analogy, by which it is extended to include the mutual induction between conductors separated by air or other insulators, and currents in solids of different conductivity fixed together in contact.

4. If the subject is heat, as in Fourier's original development of the theory of diffusion, the "*quality*" is temperature.

5. If the subject is diffusion of matter, the "*quality*" is density of the matter diffused, or deviation of density from some mean or standard density considered. It is to Fick, 33 years ago demonstrator of anatomy, and now professor of physiology in the University of Zurich, that we owe this application of Fourier's diffusional theory, so vitally important in physiological chemistry and physics, and so valuable in natural philosophy generally. When the substance through which the diffusion takes place is fluid, a very complicated but practically important subject is presented if the fluid be stirred. The exceedingly rapid progress of the diffusion produced by vigorous up-and-down stirring, causing to be done in half a minute the diffusional work which would require years or centuries if the fluid were quiescent, is easily explained; and the explanation is illustrated by the diagram of curves, Section 7 below, with the time-values given for sugar and common salt. Look at curve No. 1, and think of the corresponding curve with vertical ordinates diminished in the ratio of 1 to 40. The corresponding diffusion would take place for sugar in 11 seconds, and for salt in 3¼ seconds. The case so represented would quite correspond to a streaky distribution of brine and water or of syrup and water, in which portions of greatest and least salinity or saccharinity are within half a millimetre of one another. This is just the condition which we see, in virtue of the difference of optic refractivity produced by difference of salinity or of saccharinity, when we stir a tumbler of water with a quantity of undissolved sugar or salt on its bottom. If water be poured very gently on a quantity of sugar or salt in the bottom of a tumbler with violent stirring up guarded against by a spoon, the now almost extinct Scottish species called "toddy ladle" being the best form, or

* This subject is essentially the "electro-magnetic induction" of Henry and Faraday. It is essentially different from the "diffusion of electricity" through a solid investigated by Ohm in his celebrated paper "Die Galvanische Kette mathematisch bearbeitet," Berlin, 1827; translated in Taylor's *Scientific Memoirs*, vol. ii., part viii., "The Galvanic Circuit investigated Mathematically," by Dr. G. S. Ohm. In Ohm's work electro-magnetic induction is not taken into account, nor does any idea of an electric analogue to inertia appear. The electromotive force considered is simply that due to the difference of electrostatic potential in different parts of the circuit, unsatisfactorily, and even not accurately, explained by what, speaking in his pre-Greenian time, he called "the electroscopic force of the body," and defined or explained as "the force with which the electroscope is repelled or attracted by the body;" the electroscope being "a second movable body of invariable electric condition."

† This subject belongs to the Ohmian electric diffusion pure and simple, worked out by aid of Green's theory of the capacity of a Leyden jar (see "Mathematical and Physical Papers," vol. ii., art. lxxiii.).

* See "Mathematical and Physical Papers," vol ii., art. lxxii.

† See "Stability of Fluid Motion," Section 28 *Philosophical Magazine*, August, 1887.

‡ It is essentially a mathematical analogy only; in the same sense as the relation between the "uniform motion of heat" and the mathematical theory of electricity, which I gave in the *Cambridge Mathematical Journal* 46 years ago, and which now constitutes the first article of my "Electrostatics and Magnetism," is a merely mathematical analogy.

better still a little wooden disc which will float up with the water; and if the tumbler be left to itself undisturbed for two or three weeks, the condition at the end of 17×10^5 seconds (20 days) for the case of sugar, or $5{\cdot}4 \times 10^5$ seconds (6 days) for salt, will be that represented by No. 10 curve in the diagram.

6. If the subject be electricity in a submarine cable, the "*quality*" is electric potential at any point of the insulated conductor. It is only if the cable were a straight line that x would be (as defined above) distance from a fixed plane: but the cable need not be laid along a straight line; and the proper definition of x for the application of Fourier's formula to a submarine cable is the distance along the cable from any point of reference (one end of the cable, for example) to any point of the cable. For this case the diffusivity is equal to the conductivity of its conductor, reckoned in electrostatic units, divided by the electrostatic capacity of the conductor per unit length insulated as it is in gutta-percha, with its outer surface wet with sea water, which, in the circumstances, is to be regarded as a perfect conductor. For demonstration of this proposition see vol. ii., art. lxxiii (1855) of my collected papers.

7. EXPLANATION OF DIAGRAM SHOWING PROGRESS OF LAMINAR DIFFUSION.

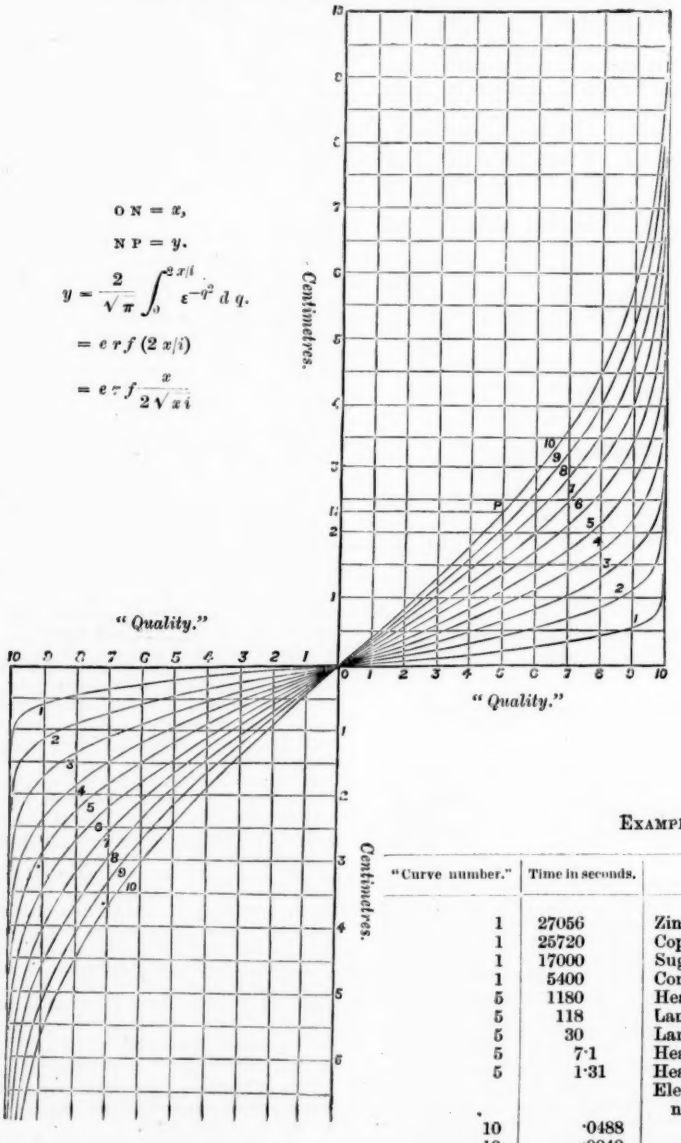
In each curve—

$$\frac{1}{10}\,\text{N P} = \frac{2}{\sqrt{\pi}}\int_0^{2x/i} d\,q \cdot \varepsilon^{-q^2},$$

N P denotes the "*quality*" (defined below) { at distance = O N from initial surface or interface, and at time equal in seconds to ["curve number"]^2 divided by 16 times the diffusivity in square centimetres per second.

Subject of Diffusion.	"*Quality*" represented by $\frac{1}{10}$ N P.
Motion of a viscous fluid ...	Ratio of the velocity at N to the constant velocity at O.
Closed electric currents within a homogeneous conductor	Current density.
Heat	Ratio of temperature *minus* mean temperature to mean temperature.
Substance in solution ...	Ratio of density *minus* mean density to mean density.
Electric potential in the conductor of a submarine cable	Ratio of potential at N to constant potential at end O.

DIAGRAM SHOWING PROGRESS OF LAMINAR DIFFUSION.



where x denotes the number of centimetres in O N, and i the "curve number." The curves are drawn directly from the values of the integral given in Table III. appended to De Morgan's article "On the Theory of Probabilities," "Encyclopædia Metropolitana," Vol. II., pp. 483—84.

EXAMPLES.

"Curve number."	Time in seconds.	Case of Diffusion.
1	27056	Zinc sulphate through water.
1	25720	Copper sulphate through water.
1	17000	Sugar through water.
1	5400	Common salt through water.
5	1180	Heat through wood.
5	118	Laminar motion of water at 10°cent.
5	30	Laminar motion of air.
5	7·1	Heat through iron.
5	1·31	Heat through copper.
		Electric current in a homogeneous non-magnetic conductor:
10	·0488	Copper.
10	·0040	Lead.
10	·0038	German silver,
10	·0023	Platinoid.
1,000,000,000	2·15	Electric potential in the Direct U.S. Atlantic cable.

ON THE TRANSFERENCE OF ELECTRICITY WITHIN A HOMOGENEOUS SOLID CONDUCTOR.

By SIR WILLIAM THOMSON.

(Section A.—Mathematical and Physical Science.)

Saturday, September 8th.

Adopting the notation and formulæ of my previous paper, and and taking ρ to denote 4π times the electric density at time, t, and place (x, y, z), we have—

$$\rho = \nabla^2 \Psi = -\text{“}v\text{”}^2 \int \left(\frac{d\,u}{d\,x} + \frac{d\,v}{d\,y} + \frac{d\,w}{d\,z} \right) d\,t \qquad (17)$$

and, eliminating u, v, w, Ψ by this and (16) from (10), we find, on the assumption of κ constant,

$$\kappa \frac{d}{d\,t} \nabla^2 \rho = \frac{d^2 \rho}{d\,t^2} - \text{“}v\text{”}^2 \nabla^2 \rho \qquad (18)$$

The settlement of boundary conditions, when a finite piece of solid conductor, involves consideration of u, v, w, and for it, therefore, equations (17) and (12) must be taken into account; but when the subject is an infinite homogeneous solid, which, for simplicity, we now suppose it to be, (18) suffices. It is interesting and helpful to remark that this agrees with the equation for the density of a viscous elastic fluid, found from Stokes's equations for sound in air with viscosity taken into account; and that the values of u, v, w, given by (17) and (10), when ρ has been determined, agree with the velocity components of the elastic fluid if the simple and natural enough supposition be made that viscous resistance acts only against change of shape, and not against change of volume without change of shape.

For a type-solution assume—

$$\rho = \text{A}\, \text{E}^{-qt} \cos \frac{2\pi x}{a} \cos \frac{2\pi y}{b} \cos \frac{2\pi z}{c} \qquad (19)$$

and we find, by substitution in (18)—

$$q^2 - \frac{\kappa}{\text{L}^2} q + \frac{\text{“}v\text{”}^2}{\text{L}^2} = 0 \qquad (20)$$

where—

$$\text{L}^2 = 1 \Big| 4\pi^2 \left(\frac{1}{a^2} + \frac{1}{b^2} + \frac{1}{c^2} \right) \qquad (21)$$

Hence, by solution of the quadratic (20) for q—

$$q = \tfrac{1}{2} \frac{\kappa}{\text{L}^2} \left\{ 1 \pm \sqrt{\left(1 - \frac{4\,\text{“}v\text{”}^2\,\text{L}^2}{\kappa^2} \right)} \right\} \qquad (22)$$

[In the communication to the section numerical illustrations of non-oscillatory and of oscillatory discharge were given.]

ELECTROMETRIC DETERMINATION OF “v.”

By SIR WILLIAM THOMSON, PROF. AYRTON, and PROF. PERRY.

(Section A.—Mathematical and Physical Science.)

Tuesday, September 11th.

THE standard measuring instruments used were an absolute electrometer and a centiampere balance, with a resistance coil for measurement of potential. Their indications of potential in electrostatic measure and in electromagnetic measure were compared by aid of two electrostatic voltmeters (A and B), which had been carefully compared in Glasgow, and which were used as intermediaries. The absolute electrostatic value of the scale of one of the intermediaries (A) was determined in London by Messrs. Aryton and Perry, using the absolute electrometer. They consider that as neither of the two instruments is capable of very minute accuracy, their determination might be three-quarters per cent. wrong, but they believe that it may be quite trusted to be within one per cent. of the truth. The voltage of the other electrostatic voltmeter (B) was determined from a potential of about 80 volts between the two ends of a resistance of 800 ohms, with a current of about 100 milliamperes through it, very accurately measured by a centiampere balance. The 80 volts multiplied 16 times by the method of condensers in series described by Sir Wm. Thomson to Sec. A at Aberdeen in 1885, gave the voltage of the B electrostatic voltmeter. As this instrument is not capable of very minute accuracy, the determination may have been wrong half per cent., but it may be trusted as probably not three-quarters per cent. wrong.

The comparison of these measurements then gave the voltage corresponding to electric potential reckoned in electrostatic units. The final result is that the electrostatic C.G.S. unit of potential is equal to 292 volts; that is to say, 292×10^8 C.G.S. units of electromotive force in electro-magnetic measure. In other words, “v” is 292×10^8 centimetres per second. This result may, we believe, be trusted to as within $1\frac{1}{4}$ per cent. of the truth. It therefore seems that “v” cannot be greater than 297×10^8, nor less than 287×10^8. We present it merely as an approximate result, and look forward to measuring this very important physical constant within one-quarter per cent. by the purely electrometric method carried out by an absolute electrometer, and intermediary electrostatic voltmeters, capable of greater accuracy than the instruments which we have used hitherto.

COMPARISON OF GASSNER'S DRY CELLS WITH LECLANCHE'S.

By W. LANT CARPENTER.

(Section A.—Mathematical and Physical Science.)

Thursday, September 6th, 1888.

Two Gassner's cells were examined, the round form having an E.M.F. of 1·317 volts and an internal resistance of 0·205 ohms, the measurements of the flat form being 1·52 volts and 0·700 ohms. The E.M.Fs. were measured by Law's condenser method, and the internal resistance by Kempe's method, the shunt employed being 1 ohm.

The resistance of a ringing bell, measured by the reproduced deflection method, was found to be 20 ohms. The two dry cells and a No. 2 size Leclanché were separately circuited for 168 hours through 20 ohms, and observations of the potential differences were made at frequent intervals. Similar observations were made during the recovery from the polarisation thus produced, and the results were plotted in curves (which were exhibited). The round dry cell was circuited through 3 ohms for 5½ hours, the potential differences and internal resistances being measured at intervals so that the current might be calculated.

From the results obtained it appeared that the round form of dry cell polarised less than a No. 2 Leclanché, but took longer to recover when the circuit was opened, and its internal resistance was considerably lower; but that the flat form polarised, in most cases, more than a No. 2 Leclanché, and had the same internal resistance.

Lord RAYLEIGH said he had had no experience of the effect of passing strong currents through Leclanchés, but would like to mention that he had had a good deal of experience in observing effects of E.M.F. for long periods of time in those cells. He found them much more constant than he anticipated would be the case. Whilst observing the effects of the E.M.F. of Clark's cells the course of operation involved the comparison of a Clark's cell with low current and a Leclanché with 10,000 ohms, and it was remarkable how the constancy was preserved from day to day and from month to month. There was an idea that a Leclanché was a makeshift contrivance, but certainly treated in that way it was possible to get a wonderful constancy out of it.

ON THE INTENSITY OF MAGNETISATION OF SOFT IRON BARS OF VARIOUS LENGTHS IN A UNIFORM MAGNETIC FIELD.

By A. TANAKADATE.

(Section A.—Mathematical and Physical Science.)

Thursday, September 6th, 1888.

EXPERIMENTS were made on bars for which the ratio of length to diameter varied from 13 to 32: the bars were subjected to different strengths of magnetising fields, and the magnetic moments thereby acquired were measured, the mean intensity of magnetisation being then calculated. The results agreed with Prof. Ewing's on bars, for which the above ratio varied from 50 to 300.

Mention is made also of some experiments by the author in 1883, wherein a magnetic field of constant strength was used to act on a mass of iron that was varied by steps. The mass consisted of iron wires which were varied in number. With a field of 46 C.G.S. units the magnetometer deflexion was sensibly proportional to the number of wires up to 10; as the number of wires was increased the ratio of deflexion to number diminished, the maximum deflexion practically occurring with 25 wires, no greater deflexion occurring with 41 wires. When the wires numbered more than 10, some of them would be thrown out of the bundle, requiring pressure to keep them in the solenoid, though the whole bundle could with care be so placed that no wire would jump out. Each wire was obviously in an unstable state of equilibrium, being under the action of opposed forces, one from the solenoid tending to throw it out, and the other from its fellow wires tending to eject it.

DISCUSSION.

Prof. ROWLAND said some time ago he was interested in this question, and calculated various formulæ, and by that means got at the self-induction of a coil with a piece of iron in it. The result was interesting, and showed that the self-induction was not dependent upon the diameter of the iron at all, but only on its length. This was an entirely different result from that given in Maxwell. He had actually tested the self-induction of a coil with iron in it, and had compared it with his formula. It came out exactly as the formula indicated. That seemed to be the same result as that expressed in Faraday's theory, that the magnetisation to which iron can be subjected depended on the exterior medium when the resistance of the iron was very small, and when it got up to 20 or 30 wires, as in this case, the resistance of the magnetic circuit was almost entirely dependent on the exterior air, and not on the iron. The result that came out in theory agreed with practice, and the formula given by Maxwell was very far out indeed, for that made it depend very much on the iron.

Prof. PERRY asked if the length in the case of Mr. Tanakadaté's experiments was great in comparison with the diameter.

Sir WM. THOMSON said the object of the investigation was to pursue to shorter proportions the investigations made in Japan,

which ended in 30 to 1. Mr. Tanakadaté pushed down to 5 to 1 in experiments with different lengths of the same quality of wire. He (Sir Wm.) was sorry that he had not with him the exact lengths.

Prof. PERRY said the result from what Prof. Rowland had said was that if you had a very short coil there was really no great object in putting the iron in it.

Prof. ROWLAND said he thought the iron increased the self-induction very much, but not several thousand times, as one text-book put it, not so much as the magnetic permeability of the iron would make one suppose.

ON FIGURES PRODUCED BY ELECTRIC ACTION ON PHOTOGRAPHIC DRY PLATES.

By J. BROWN.

(Section A.—Mathematical and Physical Science.)

Thursday, September 6th.

A RAPID bromide photographic dry plate was laid film side up on a sheet of metal in connection with one terminal of a good induction coil. A wire from the other terminal was brought down on the centre of the film. A single discharge from the coil was given and the plate developed in the usual way. If the wire touching the film were the negative pole a beautiful figure with branches carrying palm-like fronds was produced, if positive a number of irregular branches of a quite different character accompanied by a quantity of light radiating tracery extending beyond the darker branches. If the discharge took place with the two poles of the coil touching the uncoated side of the plate, other figures were produced by the electricity induced on the film, the positive and negative differing both from each other, and from those given, as before described, by the discharge on the film. If a coating of tinfoil were placed on each side of the plate after the manner of a Franklin's pane, that on the film having letters cut out like a stencil plate, the result after electrification of the foils and development was a dark irregular marking round the edge of the stencil plate foil on the film, including the edges of the cut-out parts—apparently produced by a discharge from the edge, together with irregular blotchings apparently corresponding to wrinkles in the foil. If a piece of gutta-percha tissue were placed between the foil and the film the effect was much the same. If four thicknesses intervened there were only irregular blotchings without any appearance of the outline and the letters cut in the foil. These last effects, together with some peculiarities and the figures produced by the discharge on the film itself, appeared to show that the figures were produced, partly at least, by a direct action of the electricity on the film, without the intervention of light or purely photo chemical causes as usually understood. Further investigation might show that they had here a new kind of evidence on the relations of electricity and light.

REPORT OF THE ELECTROLYSIS COMMITTEE.

DURING the past year work has been done by the committee as follows:—

Prof. FitzGerald and Mr. Turston have continued their investigation into the accuracy of Ohm's law in electrolytes. Dr. Gladstone and Mr. Hibbert have experimented on the mode of conduction of alloys and solid sulphides. Dr. Armstrong has been preparing some pure selenium with the object of examining its conductivity, and Mr. Crompton in his laboratory is engaged in determining the resistance of sulphuric acid of various strengths at different temperatures. Mr. Shaw is continuing the drawing up of his report on recent progress in the whole subject. Dr. Arrhenius has transmitted to the secretaries various reprints bearing on the dissociation hypothesis of electrolytic conduction. Dr. Richardson has also sent some papers. The work of Professor Rowland and Mr. Bell on the effect of a magnetic field on chemical action, communicated verbally to the section last year, has now appeared in a recent number of the *Philosophical Magazine*.

The most remarkable result to be recorded in the year within the scope of the committee is that obtained by Dr. Hertz, subsequently confirmed by Wiedemann and Ebel Hallwachs and Arrhenius, on the effect of ultra-violet light in making air conducting, and especially in breaking down the transition resistance or obstruction film at the cathode of an electric sparking arrangement. The fact that ultra-violet light is that which most nearly corresponds to the periods of electric oscillation in atoms suggests some chemical or dissociation cause of the effect.

PRACTICAL STANDARDS FOR USE IN ELECTRICAL MEASUREMENTS.

REPORT of the Committee consisting of Prof. G. Carey Foster, Sir William Thomson, Prof. Ayrton, Prof. J. Perry, Prof. W. G. Adams, Lord Rayleigh, Dr. O. J. Lodge, Dr. John Hopkinson, Dr. A. Muirhead, Mr. W. H. Preece, Mr. Herbert Taylor, Prof. Everett, Prof. Schuster, Dr. J. A. Fleming, Prof. G. F. Fitzgerald, Mr. R. T. Glazebrook (secretary), Prof. Chrystal, Mr. H. Tomlinson, Prof. B. Garnett, Prof. J. J. Thomson, Mr. W. N. Shaw, Mr. T. J. Bottomley and Mr. T. Gray, appointed for the purpose of constructing and issuing Practical Standards for Use in Electrical Measurements.

The committee report that the work of testing resistance coils has been continued at the Cavendish Laboratory, and a table of the values found for the various coils is given:—

LEGAL OHMS.

No. of coil.	Resistance in legal ohms.	Temperature.
Elliott 193 C.C.L. 178 ...	·99971	15°·5
Elliott 201 C.C.L. 181 ...	1·00005	14°·8

B. A. UNITS.

No. of coil.	Resistance in B.A.U.	Temperature.
Elliott 200 C.C.L. No. 71 ...	1·00049	13°·8
Elliott 43 C.C.L. No. 72 ...	·99955	14°·7

In conformity with the opinion expressed by the committee in their last report some steps have been taken towards the construction of an air condenser. A meeting was held in London, and Dr. Alex. Muirhead exhibited an air condenser, capacity about ·0035 mf. This condenser consists of a series of concentric cylinders of brass, insulated from each other by glass rods.

Dr. Muirhead expressed his willingness to send this condenser to the committee with two others of similar construction, and it was agreed that the secretary should be requested to test them, and to make a determination of their absolute capacity. Some delay in sending the instruments to Cambridge unavoidably took place, but the experiments necessary are now in progress; so far, of the £80 granted last year for the purpose, only £2 10s. has been expended.

During the year the original resistance standards of the association have been compared with each other by the secretary and Mr. T. C. Fitzpatrick; an account of the experiments is given in an appendix to the report, together with a chart giving the values of their resistances between 10° and 20°. The general result of the comparison is that with perhaps one exception the relative values of the standards between the temperatures of 10° and 20° have not changed since they were constructed in 1865 until June, 1888.

The attention of the committee has been directed by several practical electricians to the desirability of re-determination of the value of the specific resistance of copper. It is known that copper wire is now made having a resistance 3 or 4 per cent. less than Matthieson's standard. In view of the importance of copper to electricians, the committee have undertaken to make experiments on the specific resistance of copper, and wish to thank the various gentlemen who have brought the matter forward for their offers of help.

At the last meeting of the committee it was resolved, on the motion of Mr. W. H. Preece, to adopt the name 'Therm" for the Gramme water degree centigrade unit of heat.

Thus one "Therm" is the quantity of heat required to raise one gramme of water at its maximum density one degree centigrade.

It was also agreed to adopt the name "Joule" for 10^7 C.G.S. units of work. Thus a joule is equal to 10^7 ergs.

It is the work done in one second by the power of one watt, or, again, the work done when a current of one ampère flows for one second between two points, between which the difference of potential is one volt and hence a power of one watt is one joule per second. Hence, also, if we take the value of the mechanical equivalent of heat as 42×10^7 ergs., we have one therm is equivalent to 4·2 joules.

In accordance with a suggestion made at the Manchester meeting, the value of the resistance of mercury in terms of the B.A. unit has been again determined by the secretary and Mr. Fitzpatrick. They find that a column of mercury 1 metre long, 1 square mm. in section has at 0° C. a resistance of ·95352 B.A. unit, and that the value of the ohm in centimetres of mercury is 106·29.

The committee are of opinion that they should be re-appointed with the addition of the name of Mr. T. C. Fitzpatrick to continue the experiments already referred to, and with a grant of £100. They propose that Prof. G. Carey Foster should be the chairman, and Mr. R. T. Glazebrooke the secretary.

MINERS' ELECTRIC SAFETY LAMPS.

By NIGHOLAS WATTS, Assoc. M. Inst. C.E.

(Section G.—Mechanical Science.—Monday, September 10th.)

After referring briefly to the but partial success attained in modifying miners' oil-lamps to adapt the same to the currents now obtaining in collieries, and noticing the apparent suitability of the incandescent lamp as a substitute, the author describes the following miners' portable electric safety lamps, some of which he exhibits:—

The Swan Lamp.—Secondary battery. Four cells grouped together in a block of gutta-percha, which is enclosed in a wooden case. The elements are lead oxide and lead. Luminosity, 1 to 1½ candle for ten hours' duration. Weight, 7 lbs. Price, 27s. Cost of maintenance, 3½d. per week. In extensive use in South Wales.

The Schanschieff Lamp.—Single liquid primary battery. Four zinc-carbon cells, the carbon non-porous. The peculiar novelty is the nature of the exciting liquid, which is a solution of the basic

sulphate of mercury, about 36 per cent. of the salt being held in solution. The solution is sold at 4s. per gallon, of which 3s. 7d. is allowed for the same quantity of the spent liquid with its solid residue and free mercury precipitated by the cells. Luminosity (with reflector), two to three candles for nine hours' duration. Weight, about 5 lbs. Price, 30s. Cost of maintenance, 3¾d. per week. Tested at Cannock Chase, Mardy, Merthyr, and elsewhere.

The Pitkin Lamp.—Secondary battery. Four cells. Luminosity (with reflector) four to five candles for 10 hours' duration. The lamp is fitted with a switch and resistance to regulate the expenditure of the electromotive force, which if allowed to act without check, would, when the battery was started, destroy the filament. Weight, 8 lbs. Price, £2 2s. Used at Llwynypia, Ocean Colliery, Treviky, and elsewhere.

The Walker Lamp.—Primary battery. Three carbon-zinc cells in a strong brass cylinder attached to an outer case of brass or copper. The exciting liquid is a mixture of bichromate of potash, nitric acid, and sulphuric acid. Luminosity (with a reflector) sufficient to enable newspaper print to be read at a distance of 12 feet, for 10 hours' duration. Weight, 7 lbs. Price, by the gross, 32s. Cost of maintenance 1d. per day.

The Portable Electric Syndicate's Lamp.—Secondary battery. Luminosity (without reflector) 1¼ candles for 10 hours' duration. Weight, 4¼ lbs. Price, one guinea. The lamp is fitted with an automatic arrangement in connection with the incandescent lamp, whereby if an outer casing of toughened glass be broken, the current is cut off to prevent explosion of fire-damp.

The Vaughton Lamp.—Secondary battery. The electrodes are wedged tightly in the cell, rendering the battery so compact that it may be subjected without injury to much rough usage. The lamp weighs 5 lbs. It takes six hours to charge. The working cost is estimated at 1d. per day. The electrolyte used is sulphuric acid diluted with eight times its volume of water, and is renewed twice a week. One shilling's worth of acid suffices for 100 lamps for one week. The price is from 25s. to 27s. 6d.

The author concludes by referring to the questions of primary *versus* secondary batteries, and considers the position of the light on the lamp as not finally settled.

DISRUPTIVE DISCHARGES AND THEIR RELATIONS TO UNDERGROUND CABLES.

By E. G. ACHESON.

FROM among the numerous problems earnestly calling for resolutions before perfection can be claimed in underground systems of electrical distribution for arc lighting, I selected as the one presenting probably the greatest importance, and consequently, the one most desirable to solve: The determination of the cause and cure of the frequent puncturing of the insulation, especially at the terminals of lead-encased conductors when carrying high potential currents.

In a communication to the electrical press, published July 7th, 1888, under the title "The influence of the condenser on disruptive discharges," a detailed description of a series of experiments on the discharge between points in air was given, they having been made with varying E.M.Fs., and condenser capacities. These experiments resulted in the formulation of the general law expressed in the equation:

$$\frac{(\text{E.M.F.})^2 \text{ charge in coulombs}}{a} = d$$

or

$$\frac{(\text{E.M.F.})^3 \text{ capacity}}{a} = d$$

where a is a constant for the dielectric and d is the spark length; the charge being expressed in coulombs and the capacity in farads. In the same article the value of a was taken as 135 and d was expressed in inches.

While these experiments may serve as a basis or foundation to build upon, much more must be known before they will meet the requirements of the engineer operating with high potential currents, and with the object in view of obtaining at least a small portion of this required information, my experiments were extended into the more practical part of the subject, and furnished the results I have embodied in this paper.

The most probable condition of a discharge in a cable would be between the cylindrical conductor and a point or projection on the lead covering; hence the first point to determine was the striking distance between such a cylindrical body and a projection or point. Experiments were made with a point and the side of a wire, two sizes of the latter being used, a No. 8 and a No. 16 B. and S. wire gauge. There was no difference between the results obtained with the two sizes. The length of the spark was found to be about 55 per cent. when compared with that produced between points with the same E.M.F. and capacity. This difference gives a new value for the constant, a, which is found to be 263. The equation for the spark length between a point and a cylinder will therefore be—

$$\frac{(\text{E.M.F.})^3 \text{ capacity}}{263} = d \text{ in inches.}$$

The following approximate values of a have been determined, for the conditions and dielectric specified, d being expressed in inches:—

Dielectric.	Sparks between.	a.
Air	Points	135
Air	Points and wire ...	263
Paraffin and cotton ...	Point and wire ...	5,822
Ozite and cotton ...	Point and wire ...	7,759

The conditions governing the possible disruptive discharge, through the insulation of the lead-covered, grounded cable, are so numerous that it would be quite impossible to exhaustively consider them, even if the necessary data were at hand. It will, therefore, be necessary to confine the subject to the more important conditions and the exposition of the law by means of a case that might be found in practical work.

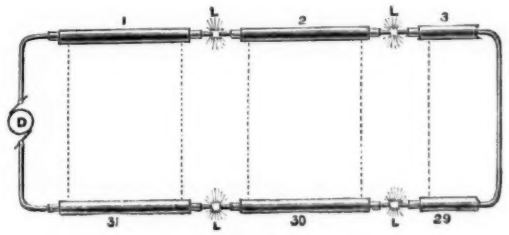


FIG. 1.

In fig. 1 is illustrated a portion of an arc light circuit, consisting of the dynamo, D, and thirty lamps, L, connected in series by lead-covered underground cable. For the purpose of illustration and calculation, it is assumed that the lamps are separated a uniform distance of 300 feet; the size of the conductor a No. 4 B. & S. wire gauge, insulated with one-tenth of an inch of cotton and paraffin; the capacity per mile is ·704 of a microfarad, and the E.M.F. at the brushes of the dynamo 1,500 volts; also as an assistance in calculation, it is supposed that the drop in the E.M.F. occurs in the lamps only. The capacity of each one of the 31 sections of cable separating the lamps and dynamo, and which are numbered in regular order from 1 to 31, will be ·04 of a microfarad, and the capacity of each division, from conductor to conductor across the circuit, as between sections 2-30, will be—

$$\frac{\cdot 04 \times \cdot 04}{\cdot 04 + 0 \cdot 4} = \cdot 2 \text{ microfarad.}$$

or in this case one-half that of one side.

With these conditions each division composed of the paired sections, as 1-31, 2-30, 3-29, and so on, will have a potential tending to break through the insulation of the lead and thence across the intervening medium in the direction of the broken lines, of a value of 1,500 volts at 1-31, and decreasing by 100 volts for each succeeding division. These various potentials will, provided the insulation is perfect and the leads well grounded, induce a static charge between the conductor and the lead of each section, of a value measured by the potential across the division and the specific inductive capacity and thickness of the insulating material.

In the case under consideration the thickness of the insulation and the specific inductive capacity are such as to induce a condenser capacity of ·02 of a microfarad, and with an E.M.F. of 1,400 volts as would exist between 2-30, the discharge would be 1,400 × ·02 microfarads ·000028 of a coulomb, and if the conductors forming the two sides of this division should, while in this charged state, be insulated from each other, as might be done by breaking the electrical continuity at both ends of either one of the sides, the energy stored within it would be able to produce a disruptive charge through air from the conductors to a point, or *vice versâ*, equal to

$$\frac{(1400)^2 \cdot 000028}{263} = \cdot 2087 \text{ inch.}$$

This is almost two and a tenth times the thickness of the insulation, but the thickness of cotton and paraffin, composing the insulation of the cable that this energy would pierce, would be—

$$\frac{(1400)^2 \cdot 000028}{5822} = \cdot 0094 \text{ inch.}$$

or less than one-tenth of the thickness of the insulation.

Two questions now present themselves:—First: Are the sides of division 2-30, or any of the others, liable to become insulated from each other, or attain a condition favourable for a discharge, for will there not always be a path open for discharge around the circuit, either by way of the lamps or the dynamo?

The second question may be stated thus:—Is it probable, with the conditions of the case above taken, that the insulation will ever be pierced, seeing that the discharge through the insulating medium cannot be greater than ·0094 of an inch, whereas the thickness of the insulation is ·1 of an inch?

It is evident that from accidental causes, such as the breaking of the circuit at two points, it is possible to have the two sides of the division insulated from each other; but such accidents are not liable to occur, especially when it is remembered that the breaks would have to be made simultaneously. To make the probability of this action occurring worthy of consideration, other means of producing it must be looked for and found.

On a circuit using coils shunted around the arc, the electrical continuity is established at each end of the two sides of the division, by one of these coils and the arc. From the experiments of various experimenters, prominent among whom may be mentioned Prof. Hughes and Dr. Oliver Lodge, it is concluded that the self-induction in these coils would be of such a value as to offer an almost insurmountable barrier to the flow of the charge through them; and this being the case the discharge, if it occurs at all, must be through either the arc or the insulation of the cable. To determine whether the charge would pass off through the arc, the apparatus shown in fig. 2 was used. Twenty incandescent lamps,

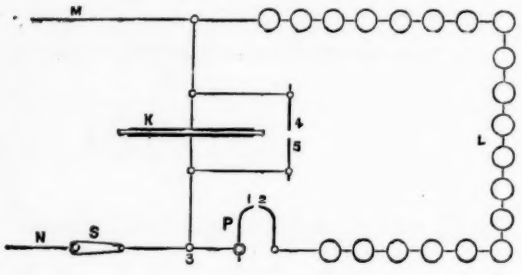


FIG. 2.

L, L, of 100 volts each, were connected in series to the lines, M, N; in the line, N, was placed the switch, S, and the contact points, 1 and 2, the former being mounted in the revolving post, P, thereby permitting of the points being opened; the condenser, K, was connected across the circuit from the line, M, at a point, 3, between the switch and the contact points on the line, N; around the condenser were placed the points, 4 and 5, with suitable means of regulating the distance between them. M and N were connected to the two sides of a transformer supplying an E.M.F. of 2,067 volts. The points, 1 and 2, being in contact, no amount of rupturing of the circuit at S, and adjusting of the space separating 4 and 5, would cause a discharge to occur between them; but upon opening the points, 1 and 2, and thus establishing an arc in the circuit, the opening of the switch, S, would cause a heavy discharge between 4 and 5. From this experiment, and Dr. Lodge's results with circuits containing self-induction, the conclusion must be drawn that conditions favourable to a disruptive discharge are exceedingly likely to occur; that upon opening an arc light circuit the various sections of the cable become, so far as the static charge is concerned, insulated from each other.

In considering the second question the fact is at once recognised, that where the constant, a, for the dielectric surrounding the conductor is that of the cotton and the paraffin, a disruptive discharge would, under the circumstances cited, be impossible; and the answering of the question in the affirmative will therefore turn upon the probable lowering of the value of a.

Anyone familiar with insulations as applied to conductors, knows that all of them, with the exception of rubber and gutta-percha and their compounds, will permit water or moisture to penetrate them, and as the hydro-carbons and water do not form chemical compounds, the one being insoluble in the other; this passage of the water must be a purely mechanical action, and, furthermore, openings, cracks, or crevices, must exist in order to permit of its passage. In many cases the cracks are visible to the eye, while in others they can only be detected by submerging the insulated conductor in water for a time and then testing it electrically. But even after proving the existence of these cracks it remains to be determined that the static charge will be influenced by them.

As one means of testing the case, a plate of glass ·072 of an inch thick was broken into two pieces and the two parts immediately fitted into their former positions and held together by clamps. The crevice or space separating the parts, was infinitesimal in width, as will be evident to anyone who may have made a similar experiment. The restored plate was placed between two discharge points, in such position that the line joining the points passed through solid glass. Under these conditions I was not able with my facilities to cause a disruptive discharge to take place through the plate; but on moving it so that the line joining the points would lie in the plane of the fracture, a disruptive discharge occurred with an E.M.F. of 2,067 volts and a capacity in the circuit of a microfarad. While this demonstrates the minuteness of the path required for a discharge, it is hardly a parallel case to what would exist in an insulated conductor, where the insulation was built up out of many overlapping windings of fibrous material, and then treated with an insulating compound, for in this case the cracks or crevices produced by temperature variations and the bending incident to handling and laying of the conductors will not be direct lines or planes from the conductor to the metallic casing, but angular or zigzag lines, following the interstices of the fibrous structure; this difference would result in the lengthening of the path of discharge, but scarcely to an extent sufficient to raise the resistance to discharge to the value of the insulating materials in a perfect state; and so long as the value is below that of the insulating material, the value of the constant, a, is also lowered, and it is therefore reasonable to assume that the conditions may become such as to warrant an affirmative answer to the second question.

Unfortunately both of the two grand divisions of conductor insulators, the fibrous and the non-fibrous, have their faults, for while the fibrous under some circumstances has the serious fault of cracking, the non-fibrous has the even greater fault of losing its insulating qualities and running off the conductor, when heated, as might occur by an accidental overloading of a circuit, and when it is confined, as in a lead covering, it permits the conductor to become decentralised and eventually come in contact with the lead casing. Between the two insulators, with the faults specified, inseparably associated with them, there would, for high potential currents, be little or no choice, but fortunately means have been devised whereby the existence of the cracks or crevices in the fibrous insulating envelopes, when properly protected from water by a metallic casing, is immaterial, as they are sheared of the power of diverting the discharge into the paths opened by them. These ends are accomplished by the simple expedient of causing the discharge to occur at such a place and in such a manner as not to pass through the insulating envelope. This may be done in a great variety of ways, but the most simple one that has suggested itself to me, is shown in fig. 3, where A is the lead covering, I the insulation, C the conductor, and P a wire connected to A and extending out beyond I, its end, K, being adjusted in relation to C so as to leave an air space slightly less than the thickness of the insulating material, I. Under these conditions when a discharge occurs it will invariably be at K and not through I. While this simple arrangement illustrates the action and answers as a means of protection, it is evident that some device more durable and capable of adjustment would be preferable. A design meeting these requirements is shown in fig. 4.

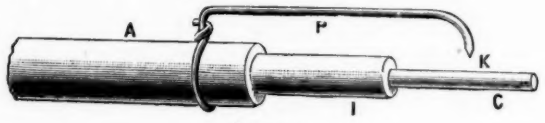


FIG. 3.

In fig. 4, A is the lead covering; I the insulation, and C the conductor. Mounted on the lead, A, and held in place by the band, V, is the metallic arm, P, carrying at its outer end the pointed rod, R. Another pointed rod, R', is held by a projection on the ring, B, which is mounted on the insulating brushing, D. A fusible wire, F, connects the ring, B, to the metallic sleeve or collar, E. The distance between the points, R and R', can be adjusted and the rods held in position by suitable screws. It is evident that the operation would be similar to that of the device shown in fig. 3. The electrical potential between the conductor, C, and the lead covering, A, before attaining a height sufficient to discharge through the insulation, I, will discharge across the air space between the rods, R and R', for these rods being in electrical connection with A and C, will attain their potentials, and the points of the rods will, according to a known law, have an electrical density above that of A and C, or that requisite to produce a discharge across the intervening air. The fusible wire, F, is inserted as protection against injury to dynamos and cables in case of a ground existing on the other side of the circuit. There are several points, apparently trivial, but really of much importance, relating to the design and material of construction of a device for discharging a cable. The distance, measured on the exposed surface, separating the points of support of the discharging arms or rods, should be as great as possible, as there would be a loss of energy, across this space, in case the distance was small and dampness existed. Another point to remember is that the constant, a, should have a known value, and therefore the most appropriate design for the discharger is one employing points to discharge from and an unvarying intervening medium, such as air.

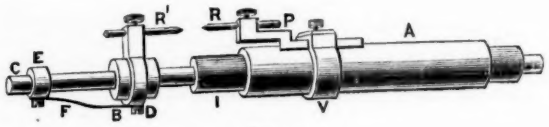


FIG. 4.

In order to obtain some definite information on the question raised by Mr. Leggett at the Pittsburgh meeting, as to the effect on the insulation, of a short bend or indentation in the lead of a cable, I caused a very deep dent to be made in a cable, so deep, in fact, that it would at once have been condemned in practical work, and then connecting it into the working circuit an attempt was made to cause a disruptive discharge to pass through the compressed insulation at the point of indentation, but the attempt was unsuccessful, the discharge preferring to occur at any other point.

Another experiment was made to determine the effect of bending the cable backward and forward several times in the same place. A length was selected in which the discharge always occurred at either one of the ends, and after the bending operation had been performed a number of times, I was able to produce the discharge through the bent portion in preference to the terminals. These tests show the superior strength of the insulation in the more condensed or homogeneous forms, and the weakening effect of much bending.

In this connection it may be well to inquire more fully into the tendency of the discharge to occur at the terminals of the lead. It is a well-known fact that the greater number of the grounds or burn-outs occurring on arc light circuits are at the terminals of the lead, or at the joints, and it is precisely at these points that the charge, acting under well established and familiar laws, would be most dense, and owing to the presence of the edges or points for the electricity to flow from, the disruptive discharge will under ordinary circumstances take place between the edges or points, and the conductor within the insulation. Owing to the special facilities offered at these places for the passage of the discharge, it is probable that in many cases burn-outs occur under the influence of a charge that would be unable to produce a discharge through the continuous portions of the cable. In order to reduce the probability of a discharge occurring at terminals and joints, I would suggest that the lead whenever cut be made bell shape, in order that all edges or points be turned away from the conductor.

It may be appropriate at this point to consider briefly that vexed question, Which way does the spark pass? There is a relic of the past ages still existing, to a greater or less extent, among those who are unfamiliar with the present state of electrical science, and which I have no doubt many, if not all of you, have heard. The favourite way of expressing it is thus: "The earth is the home of electricity, and it is continually striving to get there by the quickest and shortest route." By this theory the electricity as represented by the spark would always jump from the conductor to the lead, and thence pass to the earth. It is plain to see the great weight this would have in an argument against the near approach of the conductor to the earth as is necessitated in the underground system of distribution. The direction of the discharge is determined by the form or figure of the charged bodies and the characters or signs of the charges on them, the earth playing no part other than that of a conducting medium. On the underground system there is, the moment before a disruptive discharge occurs, an unstable equilibrium between two points of the system or rather of the conductors forming the system and the insulations or dielectrics separating them. Through the line joining the points there is a strain produced by the difference of potential of the points, the tendency being to a neutralisation of the potential differences. Against this strain is opposed the resisting power of the dielectric intervening, and usually consisting of the insulations on the conductors and the earth which separates them. The disruptive discharge that follows may be either from a conductor to the earth or the reverse, but in neither case is there the slightest quantity of electricity left in the earth as a result of the discharge. It is a transmission of energy from one point of the system to another of a different potential, and the amount of electrical energy lost in the passage is expended in overcoming the resistance, and appears as heat.

From the experiments and conclusions of Faraday, I have made the following deductions:—

1. When the charged bodies are of the same size and form, the *spark discharge* will, other things being equal, be from the positively charged body.

2. Other things being equal, less potential is required to produce a *brush discharge* than a *spark discharge*, and when it does occur, it will be from the negatively charged surface.

3. In all cases where the charge of electricity is on, or closely associated with the discharging surfaces, a diminution of either surface will facilitate a discharge, and when any considerable difference exists in their areas, the discharge will always be from the smaller surface.

4. A spark from a small body to a large one, will be from eight to ten times greater in length, when the small body is charged positively, than it would be with a negative charge.

In general, the direction of the discharge between the conductor and the lead, through the insulation, is subject to the form of the surfaces of the conducting bodies; a slight burr or point on either one being sufficient to determine the direction of the spark.

In a series of very interesting articles by G. L. Addenbrooke, in the London ELECTRICAL REVIEW, the subject of spark length, disruptive discharges, and the advantages of a perfectly continuous and unbroken dialectric are extensively treated. The influence of the capacity of the cable is, however, entirely neglected. Special stress is laid upon the advantages of a continuous envelope of insulation, and those using rubber-covered conductors are particularly cautioned against handling or bending them when the temperature is lower than 45° F., as fissures or cracks are then liable to occur, and permit of the passage of discharges. This, I confess, was information to me, and puts a certain limitation to the qualities I have given to rubber in the paper which was written before the statement of Mr. Addenbrooke came into my hands.

As the experiments referred to in this paper have extended over a considerable period—not less than six months—there have naturally been a number of questions and points presented from outside sources. Others have been led into the field to experiment, and with the equally natural result of obtaining in some cases effects that they have construed to be at variance with those I have secured. I have one case in mind where the experimenters found it impossible to produce a disruptive discharge so long as the lead of the cable was insulated from the ground, but the grounding of it made the production of the discharge feasible, and they concluded that the theory of a disruptive discharge was not correct. This is a repetition, under different conditions, of the very old experiment of attempting to charge a Leyden jar with the jar insulated. The first condition to be arrived at in the charging of a jar is the grounding of one of the surfaces. A disruptive discharge through the insulation of the cable cannot occur without a charge being first formed, hence it is absolutely necessary that a ground be made to the lead. The resistance of the ground connection to the lead is, to a very great extent, immaterial, as the charge is cumulative, and the energy expended in the discharge is only that held in the charge, hence though the ground resistance may be many megohms in value, and the charging process extend through a considerable time, there will eventually be a storage of energy on the surface of a value sufficient to rupture the insulation at the first change in the charging current. The spark discharge is all but instantaneous in its action, and with the work restricted to this immeasurably short space of time it is necessary to leave the energy on hand, as it were; there is no time to generate it, electrically, at the dynamo and convey it over long or even short distances. The subject of disruptive discharges with various resistances and self-induction placed in the path of energy, is beautifully treated in a paper read by Dr. Oliver Lodge before the Society of Arts, April 17th.

One word more before closing this subject. It is safe to predict that the disruptive discharge being provided for, little or nothing more would be heard of the much talked of pinholes in the lead, and the moisture-absorbing terminals; the undergrounding of arc light cables would become a thing of certainty, and our municipal governments relieved of a great bug-a-boo.

REGULATING ALTERNATING CURRENT DYNAMO-ELECTRIC MACHINES.

By W. LOWRIE.

Hitherto the great difficulties connected with the regulation, in a very sensitive manner, of even continuous current dynamos, have not been satisfactorily overcome.

The method usually employed in a series constant current system is that of a shunt being placed across the fields of the dynamo, which is actuated by magnetism in a coil or solenoid through which the main current passes, which actuation increases or decreases the resistance of the shunt, according as the current falls too low or rises too high.

Or in the case of a shunt-wound dynamo with which a constant electromotive force is desired, the coil, which is one wound with fine wire and of high resistance, is put right across the poles of the dynamo, and the resistance, which before was used as a shunt across the fields of the dynamos, is now put in series with them, so increasing or decreasing their resistance, according as the current rises too high or falls too low.

But in both these cases the sensibility of the regulator must depend upon the mechanical perfection of design, so making an instrument sensitive enough to correct an error of 1 per cent. an exceedingly difficult one to manufacture, and which when obtained would be quite impracticable for every-day use.

If the difficulties of regulating continuous currents are great, much more so are those of regulating alternating currents, with which the use of magnetism is practically not available; so leaving the thermal effects of the current alone available, as a means of keeping a constant electromotive force across, or a constant current through, the terminals of the dynamo.

The method adopted in the Lowrie Hall system for utilising these thermal effects is—the use of a wire rigidly attached at its extremities and weighted at the centre: then the sag formed in the wire by the central weight, when the wire is expanded by the heat generated by the passage of the current, gives a very efficient and sensitive motion.

The diagram, fig. 1, shows very clearly the great advantage of using the sag system.

Let A, A, be the wire rigidly connected at its extremities, A, A, whose centre is c.

Suppose the increase of this wire by expansion to be a length equal to $c\,b$.

Then the half of the wire, A c, will increase to A d, where $c\,d = d\,b$.

From the centre, A, describes the arc, E d, cutting at E the line c E, drawn from the point, c, which line is perpendicular to the normal position of the wire when cold.

Then the point, E, is that to which the centre, c, would fall if the expansion is $b\,c$. Join A, E.

Then since in a right angled triangle the square of the hypotenuse is equal to the sum of the squares of the other two sides

$$\therefore \quad (\text{A E})^2 = (\text{A } c)^2 + (c \text{ E})^2.$$

$$\therefore \quad (c \text{ E})^2 = (\text{A E})^2 - (\text{A } c)^2.$$

$$\therefore \quad c \text{ E} = \sqrt{(\text{A E})^2 - (\text{A } c)^2}.$$

Take, as an example, the wire to be 60 inches long, and its expansion to be one-quarter of an inch—

Then the sag of the wire

$$= \sqrt{(30 + \cdot125)^2 - (30)^2}$$
$$= \sqrt{907\cdot5 - 900} = \sqrt{7\cdot5}$$
$$= 2\cdot74.$$

Thus giving a motion of 2·74 inches for an expansion of ·25 inch, or equivalent to a gear multiplying eleven times, with none of the friction or other cause of loss of sensibility appertaining thereto.

Fig. 2 illustrates the practical method of utilising this system of regulation, it is a diagram of the connections as used with an alternating current system, in which it is necessary to keep the electromotive force, across the terminal of the dynamo, constant.

Across the terminals of the converter, M, two fine wires, E and F, supported between the fixed points, Z, Y, and Z^1, Y^1, whose normal positions when cold are shown by the dotted lines, are connected; the two wires being in series with one another, and connected by the wire, Y, Y^1.

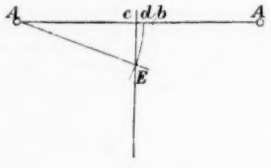


FIG. 1.

The field magnets of the dynamo, A, are excited by the exciter, B. Across the fields of this exciter a shunt of varying resistance is placed, connected by the wires, d, d^1; this shunt resistance is formed by two metal plates dipping in the solution in the electrolytic cell, D, and its resistance is altered by the raising and lowering of the plates into the solution, which is accomplished automatically by the passage of a current through either the top coil, C, which lowers them, or the bottom coil, C^1, which raises them, by their attraction for a moveable iron core inside the coils.

This core is attached to the plates by a cord passing over a pulley, d^2.

To the centre of the wire, E, a cord is attached, the other end of which is fixed to the arm, e, of the rocking arm, e, e^1, this arm is pivoted at e^2 on a fixed support.

If now the electromotive force of the dynamo rises too high, the sag becomes greater, and the arm, e, is pulled down by the weight, e^3, and so makes contact on the table, c; if, however, the electromotive force falls, the wire pulls the arm, c, up, so causing the other arm, e^1, to make contact with the table, c^1.

To the centre of the wire, F, the cord, f, is attached, which raises or lowers the arm, f^1, pivoted at its end, off or on to the table, f^3.

This table, f^3, is connected to one pole of the exciter, and the pivot of the arm, f^1, is connected by the wire, f^2, to the pivot of the rocking arm, e^2; the table, c, is connected to the top coil, C, and the table, c^1, to the bottom coil, C^1, the other ends of these two coils being jointly connected to the other pole of the exciter.

If now the electromotive force of the dynamo rises too high, the arm, e, falls, so making contact with the table, c, the electromotive force of the exciter is therefore right across the coil, C, one side being in metallic connection, and the other being connected through the table, f^3, up the arm, f^1, through the wire, f^2, to the arm, e, so passing through the table, c, connected with the coil, C.

This coil coming into action pulls the core up and so lowers the plates into the solution, which therefore lowers the resistance of the shunt, so causing less current to pass round the fields of the exciter and consequently weakening the field of the dynamo, A, so lowering its electromotive force.

These coils, it should be mentioned, are wound with fine wire and are of high resistance, so their connection across the exciter has no effect upon the dynamo, A.

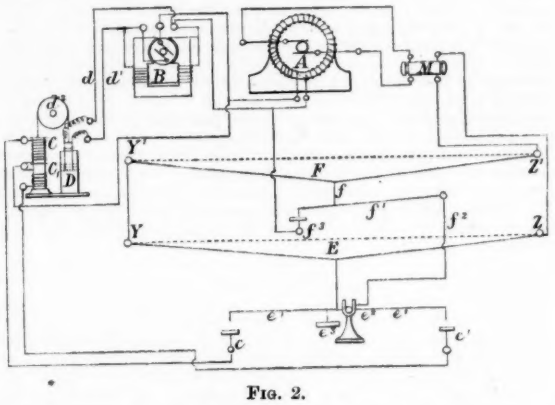


FIG. 2.

If, however, the electromotive force is too low, the arm, e^1, touches the table, c^1, so shunting the current through the coil, c^1, which coming into action raises the plates out of the solution, and consequently the resistance of the shunt, so that more current passes from the exciter round the fields of the dynamo, A, whose electromotive force therefore rises.

The arm, f^1, is put in to cut out the action of the regulator in the event of the wire, E, breaking, for that wire by breaking would stop the passage of the current through the wire, F, so making the latter contract and pull up the arm, f^1, so breaking its connection with the table, f^3.

If no provision is made for this accident the arm, e, by making permanent contact with the table, c, would lower the electromotive force of the dynamo as far as the shunt would allow.

In the event of using this system for the regulation of an alternating current driven direct from the dynamo, the only alteration in the connections is that instead of connecting the wires, E and F, to the converter, they would be connected to the dynamo.

Fig. 3 is a complete regulator, comprising the shunt resistance and the sagging-wire arrangement; figs. 4 and 5 show the electrolytic cell arrangement in front and side elevation.

In the shunt resistance the two plates, which are fixed to an insulating piece, dip into the solution contained in the glass cell. The plates are supported by two chains, which pass over the two ebonite wheels; these chains make connection with the plates and terminate at two terminals, having sufficient slack to allow the wheels to turn their maximum distance either way.

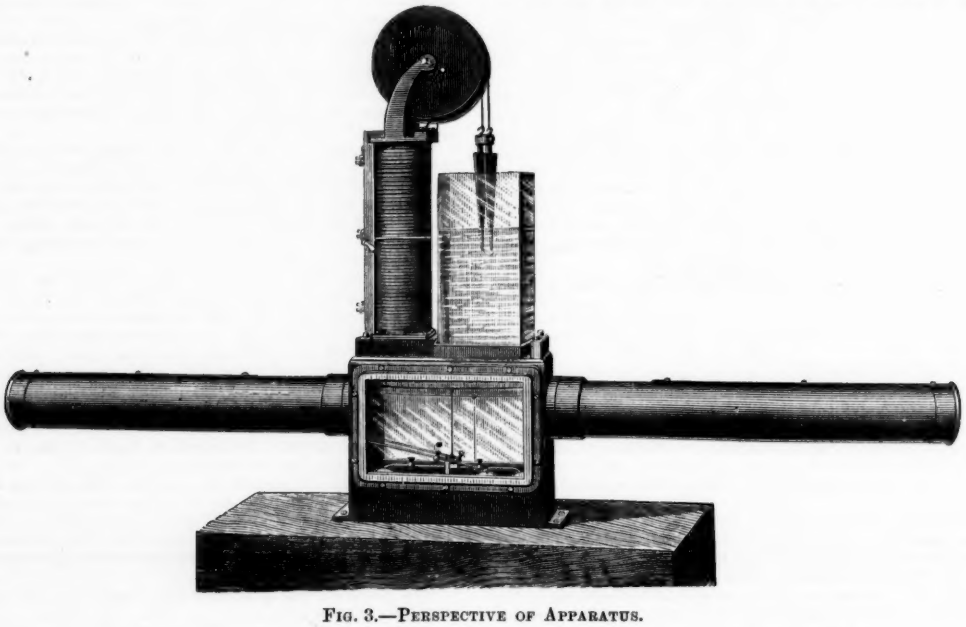


FIG. 3.—PERSPECTIVE OF APPARATUS.

On a smaller pulley a chain is fixed, supporting the iron core, which moves up or down in the coils; the speed of the motion of the plates is increased or decreased by the ratio of the diameters of the pulleys. The coils are wound upon a brass tube, which is filled with glycerine to act as a dash-pot, the core acting as a plunger itself.

The plates in the shunt resistance cell should be charged periodically to reverse the chemical action of the current upon them.

In the instrument designed to utilise the sag of the wire, the wires are stretched in a brass tube in the centre of which is a containing box; at each end of the tube is a disc or insulation; on one of which are two moveable brass strips to tighten the wires by the action of the thumbscrews.

These are used to adjust the instrument; on each of these strips is a terminal, so that they make electrical connection to the wires.

At the other end of the tube a brass piece is fixed, on to which both wires are screwed.

The rocking arm is jewelled in both movements.

The use of the guiding arm is to bring the centre pin on to the bridge, so that when the current ceases, the wire is free to contract.

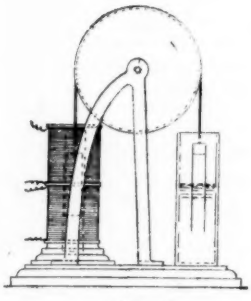


FIG. 4.

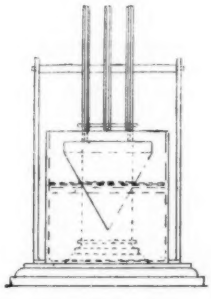


FIG. 5.

All the contacts are made of platinum, and the connections to the tables are made in the terminals underneath; these tables are all adjustable from below, so that their height may be altered, without allowing cold air to get in whilst the current is on. The use of the other arm as a cut-out has already been described.

To regulate a continuous current series wound dynamo, working on a series system of arc or incandescent lamps, the current after leaving the dynamo, and passing through the entire circuit, passes through the coils, which are precisely similar ones in the number of turns, and which actuate a sucking core, whose movements raise or lower the plates in the electrolytic cell, which is connected as a shunt across the field magnet coils of the dynamo; it then passes through a resistance coil, and returns to the negative pole of the dynamo.

The sagging wires are connected together in series and placed as a shunt across the resistance, so that a portion of the current sufficient to cause the necessary dip from expansion due to the thermal effects passes through them.

The use of one wire is that of a cut-out as before described.

The action of the arms is to short-circuit one coil, so bringing the other into action, and consequently varying the resistance of the shunt.

It will be seen that in both these cases another method of rendering the instrument still more sensitive or the reverse, is by moving the attachment of the cord on the rocking arm nearer to or farther from the pivot.

NOTES FROM DENMARK AND NORWAY.

THE authorities of the City of Copenhagen have issued some important regulations respecting the use of electrical plant in that city, of which the following are the principal :—

The dynamos must be placed in a spot remote from combustibles, and must, when at work, always be tended by a man. The electrical tension must in no case exceed 200 volts, and alternating currents are only by special permission. All wires must be entirely isolated, and in the streets encased in iron tubes. Wires must not be concealed in buildings in the plaster of Paris or stucco in ceilings, whilst looping must be avoided as much as possible. At every house a switch must be fitted in an easily accessible place for the use of the police or firemen in case of fire. Wires of arc lamps must not run closer to each other than 4 inches, and in the case of glow lamps 2 inches. In the conductors in buildings a connecting or safety wire of some metal easily melted must be inserted, so that the current is interrupted when reaching double the strength of the force allowed, and these connecting links must be entirely isolated. All arc lamps must be fitted with a guard for preventing the fall of chips of carbon outside them. Arc lamps must on no account be used in factories where combustible or explosive articles are manufactured, but glow lamps may be used if fully protected by glass globes. The diameter of the wires shall be 1 square mm. where the current is under 50 ampères, and 2·5 mm. when above 50 but less than 100 ampères. The fire brigade and the municipal electrical engineers shall at all times have access to the electric plant.

The great Carlsberg Brewery in Copenhagen—the largest in Scandinavia—has just been fitted throughout with the electric light, the plant being also no doubt the most extensive electrical plant in the three kingdoms. There are two dynamos, capable of feeding 1,000 glow lamps of 16 candle-power, driven by four steam engines of 120 horse-power. The plant has been supplied by Messrs. Koefoed & Hauberg, of Copenhagen, the dynamos being of the latter's construction.

The Telephone Company of Copenhagen have just laid 520 new subterranean cables in that city from their new central office, enclosed in iron tubes, 2½ inches in diameter. The new cables are 5 miles in length, and the wires about 250 miles. The whole plant has been furnished by Messrs. Felten & Guilleaume, of Mulheim-by-the-Rhine, who also supplied the older telephone net. Some new multiple tables have also been introduced, of Swedish manufacture, whereby the service is greatly accelerated, whilst, in order to facilitate the working, a uniform charge of £8 10s. per annum for telephone subscribers has been adopted for the whole city, whereas hitherto the charge varied according to distance.

On the other hand, the corporation, seeing the extensive business done by the company, has decided upon imposing a tax on each apparatus of 5s. 6d. a-year, in addition to a number of regulations, of which the most important are that the company cannot extend its plant without the sanction of the municipal council, and that the whole plant and business may at any time be purchased by the latter on a valuation of two valuers, one to be selected by each party. Moreover, every apparatus must, before being taken in use, be sealed by the council. Otherwise the company's concession will be in force for 30 years, but should its engagements towards the public or the municipal council be in any way broken the concession is forfeited.

Eleven towns in the island of Lealand are now connected by telephone with Copenhagen, and there are telephones in 40 Danish cities altogether, and in the near future it is expected that communication will also be established with Sweden (Malmo) 40 kilometres, and the capital cities of Jutland and Funen—Aarhuus and Odeuse—180 and 165 kilometres respectively. It is estimated that the Danish telephone net will soon extend over 1,000 miles.

Turning to the Danish telegraphs we find that a new submarine cable has just been laid between Denmark and Germany—from Gjedser to Warnemunde—by the German firm named above. Its length is 50 kilometres, and it contains four wires. It is laid at the joint cost of both countries, but will be maintained by Denmark.

In Norway the electric light is making remarkable progress, particularly in the lighting of saw mills and factories, glow lamps being preferred. The light has also been introduced into the city of Skien, for indoor lighting only. The motive power is a water turbine capable of feeding 3,000 lamps of 16 candle-power. Some of the lamps have, however, a force of upwards of 50 candle-power. The charge per lamp of 16 candle-power is 27s. 6d. a year. Arrangements are also being made for a central electrical station in the city of Frederickhall, to be driven by a neighbouring waterfall 800 yards distant, capable of developing 300 horse-power. The plant at first will, however, only be capable of lighting 1,200 glow lamps. In Christiania

the gas company will shortly be compelled to lower the price of gas in consequence of the competition of the electric light, although gas is considerably cheaper in the Norwegian capital than in Stockholm and Copenhagen, but as yet no steps have been taken by the corporation, as contemplated, to establish a central municipal station. It is evident, by the way, that with the great facilities for motive power offered by the waterfalls, the electric light can be employed in Scandinavia much cheaper than in many other countries.

Several Norwegian mail steamers have also been fitted with the light of late, and on board one experiments are to be made with a submarine lamp of 200 candle-power, in order to try its effect in deep-sea fishing.

The first attempt to use the electric current as a motive power in Norway is being made at the works of the Electrical Bureau at Christiania, where some of the machinery is thus worked.

The telephone net of Norway is also becoming more and more extended, and there is even an agitation on foot for connecting every town in the whole country in this manner. This year the Government has granted the necessary funds for an extension of the net in central Norway, amounting to 270 kilometres, which will greatly benefit tourists travelling in these parts. The plant is supplied and laid by Messrs. Mourlon and Company, of Brussels. The Bell Company, which is established in the city of Drammen, has obtained powers for further extension of wire and concession; so also has the Bergen Telephone Company, of Bergen.

From the report just issued of the Christiania Telephone Company, it appears that the number of subscribers rose in 1887 from 1,488 to 1,632, there being nine offices. The average number of conversations per day was 9,000. The gross receipts amounted to £7,500, and the expenditure to £4,500, leaving a profit of £3,000; but the bulk of this will be employed in the maintenance of the plant. However, the dividend paid was 5 per cent. The charge in this city is now 88 shillings per apparatus a year within 1½ kilometre from the central station, and 8s. 6d. extra per ½ kilometre beyond.

In Norway and Sweden, by the way, the Governments have the monopoly of the telephone, but concessions for a limited number of years are granted to private companies.

From the report of the Norwegian telegraphs in 1887, just issued, it appears that 834,800 messages were transmitted, being 21,300 less than in 1886. The foreign correspondence was greatest with Great Britain, viz., 35 per cent., Germany coming next with 19½ per cent. The receipts were £46,000, against £48,000 in 1886, and the expenditure £10,500; the profit being thus £35,500. The number of *employés* was 450, including 92 ladies. From January 1st, 1888, the charge for inland messages was reduced from 1 Rs. (1s. 1½d.) for 15 words to 6½d. for ten words, with ¾d. for every three words extra. By way of comparison, it may be mentioned that in Sweden the charge is 1s. 1d. per 15 words, with 3d. per 10 words extra; in Denmark, 6½d. per 20 words, with 3d. per 10 words extra; and in Germany 8d. per 10 words, with ¾d. per word extra.

Breakdown of Electric Light.—The readers of the *Daily News* this morning, wrote the London correspondent of the Birmingham *Daily Post* on the 22nd inst., could not have guessed how nearly they were deprived by an accident last night of the customary supply of their favourite pabulum. Owing to something becoming amiss with a "drum," the supply of electric light broke down, and had there not been gas in reserve, the composing and machine rooms in Bouverie Street would have been in darkness. The offices of the *Times* and the *Daily Telegraph* also are it by electricity, but in each, I believe, the same precaution as to a reserve of gas is adopted in order to correct any accidental eccentricities of the new illuminant.

NOTES.

The Strand and the Electric Light.—At the fortnightly meeting of the Strand District Board of Works, Dr. Sandwell brought up the report of the Lighting Committee with regard to the lighting of the Strand by electricity. They said they had considered an application by the London Electric Supply Corporation, Limited, for permission to run a cable through Carey Street and across Portugal Street to the rear of the Royal College of Surgeons. The company had entered into an agreement with the vestry of St. George's, Hanover Square, in regard to a somewhat similar application in reference to that district, and the committee advised that the Board did not refuse the application, subject to the company's obtaining evidence that objection was not raised by the King's College Hospital or the Cook's Court Improvement Company, and to the applicants signing a similar agreement with this Board to the one before referred to, with an addition that if the Board should consider it necessary to remove the cable, or in the event of damage done to it, the Board was not to be liable to the company. The committee had considered the various applications before them in respect both to licences and provisional orders for supplying the district with electricity. They were of opinion that the Metropolitan Electric Supply Company, Limited, presented the greatest advantages for the supply within the district, and therefore recommended the Board to approve the granting of a licence by the Board of Trade to that company. The report was adopted.

Electric Lighting at Flint.—Last week the chlorate of potash factory which forms part of the extensive chemical works of Messrs. Muspratt, Brothers, and Huntly, Limited, at Flint, was lighted for the first time by electricity. The dynamo is a "Manchester," manufactured by Messrs. Mather and Platt. The engine is regulated by one of Hartnell's automatic regulators and made by Messrs. Marshall & Son, Gainsborough. The dynamo is driven off a seven foot flywheel. The railway siding is lighted up by five lamps of great power; the dynamo room by two incandescent lamps similar to those in other rooms throughout the building. The inside lamps vary in candle-power from 16 to 50, and altogether make up an installation of between 60 and 70 lights. The installation has been laid down by Mr. A. W. Bennett, electrician, Leeds, under the superintendence of Mr. J. Scott.

The City and the Electric Light.—At the last meeting of the City Commissioners of Sewers, Mr. J. V. Moore asked the chairman of the Streets Committee whether he could give the court any information on the subject of the electric lighting of the City. Mr. Bridgman said, although the new Act with reference to electric lighting dated only from this year, the committee had very effectually commenced to grapple with the question, and had come to a resolution to refer the matter to the engineer and solicitor to take the opinion of Mr. Preece, and to report on the matter generally, in order that the committee might have drawn up certain conditions on which the electric lighting companies might be asked to send in tenders for lighting the City. Several communications had been received from these companies, and their consideration had been adjourned in order that the committee might deal effectually with them when they got the report.

Ilfracombe and the Electric Light.—The Ilfracombe Local Board is advertising for tenders for lighting the public lamps in the town for a period of three years, either by electricity, gas, or oil. Specifications may be obtained on application to Mr. W. H. Gould, surveyor, and tenders are to be sent in by December 1st.

Mill Lighting.—Messrs. John Hilson and Sons, woollen manufacturers, Canongate Mills, Jedburgh, have made arrangements to have their mills supplied with the electric light.

Malvern and the Electric Light.—The *Malvern Advertiser* publishes a letter from a correspondent, and a leading article of its own, strongly advocating the adoption of the electric light for the lighting of the streets of the town.

Electric Lighting at Reefton.—A public trial of electric lighting was made in the Broadway at Reefton, N.Z., on the night of August 4th. The *Otago Witness* says:—"A large arc lamp was suspended in the street and at 7 p.m. the machinery was set in motion and the powerful light diffused itself all over the town, illuminating the hills and giving a most weird aspect to the whole scene. The light was somewhat unsteady at first, but after an hour or so a more even current was maintained. Inside the Oddfellows' Hall 20 or 30 16-candle-power lamps with various shaped and coloured shades were brilliantly lighted and made up a most dazzling scene. The light was much admired and was perfectly steady. The trial is considered eminently successful, and on Monday next the work of connecting the houses with the mains will be started. The installation was carried out by Mr. Walter Prince, of Dunedin. The motive power is supplied by a turbine fed by a water race giving 24 feet fall and capable of exerting 120 horse-power. Sixty horse-power, however, will provide the lighting system. The machinery ran very smoothly, and the whole work appears to have been carried out in a thoroughly efficient manner."

Football by Electric Light.—The Walsall Town Swifts met the West Bromwich Albion at Walsall last Monday night, a good game ending in a draw of two goals each. The match was played by electric light, the occasion being the fêtes held in connection with the opening of a new Science and Art Institute. Nearly 7,000 persons were present.

Maidenhead and the Electric Light.—The Town Council of the borough of Maidenhead invites tenders for the lighting of the streets by electricity. Fuller particulars may be obtained by reference to our advertisement columns.

Electric Light Display.—The Cincinatti Exhibition boasts of an extensive display of electric lighting. The Western Electric Company provides eight dynamos and 225 arc lights; the Waterhouse Electric Company eight dynamos and 230 arc lights; the Edison, Queen City, and Mather companies equally divide a show of 3,000 incandescent lamps and six 500-light dynamos.

Successful Electric Lighting.—The Chicago municipality is likely to be a considerable gainer from the use of the electric light, putting aside the question of improved illumination. It is stated that the annual cost of each gas lamp ranges from £5 to £6, while the electric light is said to cost £3 per lamp per annum.

Berlin Theatres and the Electric Light.—The following is a list of the Berlin theatres illuminated by the electric light:—

The Royal Opera ...	... 5,000	incan. lamps.	
„ Comedy Theatre	... 2,000	„ „	
„ German „	... 1,200	„ „	
„ Barnay „	... 1,250	„ „	
„ Kroll „	... 300	„ „	and 26 arc lights.
„ Reichshallen Theatre	... 600	„ „	
„ Friedrich Wilhelm Stadt Theatre	... 1,200	„ „	
„ Lessing „	... 1,000	„ „	
„ Residenz „	... 1,000	„ „	
American „	... 200	„ „	

Electric Light Circuits and the Telephone.—The New York *Electrical Engineer* states that the telephone subscribers in Quincy complain that the turning on of the electric light currents at night seriously interferes with their communications on account of the loud buzzing produced. The telephone and electric light circuits are, to a great extent, carried on the same poles.

Electric Lighting Compulsory.—It appears that the Italians are to a certain extent following in the footsteps of the Spanish authorities, inasmuch as the Turin municipality has decreed that all the theatres in that town must be lighted by electricity from the 1st November proximo.

Electric Light in Vienna.—Last week the inaugural lighting of the Hofburg Theatre took place. The installation consists of 5,000 lamps of 10 to 40 candles.

"How they do Business at Indore."—Under this heading the *Morning Post* of Allahabad tells a curious story anent the Maharajah Holkar and the electric light. The capital of Holkar's state is a collection of hovels, and scarcely the place one would expect to find illuminated by electric light. Holkar, however, conceived the idea that nothing short of the electric light was sufficient, and communications with a Bombay firm of electricians resulted in an electric lighting plant being sent up to Indore in charge of Mr. A. B. Simpson, the Maharajah undertaking to defray the expenses of the trip if he did not purchase the plant. Arrived at Indore, Mr. Simpson found he had no ordinary task before him. Having fitted up his plant, after considerable trouble, in a bungalow assigned to him for an experimental illumination, he was suddenly informed by the Maharajah's officials that His Highness was desirous that the experiment should take place at the palace. The plant had all to be taken down, removed, and refitted; yet the next evening word was brought from the palace by a breathless messenger that unless the lights were in position next day by an early hour His Highness would refuse to take them at all. By working through the night Mr. Simpson was prepared to give an exhibition next day, but was coolly informed that it was a Friday, and, therefore, the Maharajah could not concern himself with any new undertaking. On Saturday came the intimation that, as the monsoon had commenced, the Maharajah was unable to be present at the trial, and, moreover, His Highness did not consider that season a good time for the purpose, and he therefore wished Mr. Simpson to go away and take his lights with him. "Expenses!" exclaimed the officials, when that subject was mentioned, "His Highness knows nothing about them." Mr. Simpson produced a letter guaranteeing payment of 1,500 rupees, and it was admitted that the document was genuine. The officials implored him not to persist in claiming these expenses, because, said they, the Maharajah had declared that if it became necessary to pay he would deduct the sum from their salaries. As the man highest in power in the State receives only 40 rupees a month, it will be seen what a serious threat this was. Nevertheless, Mr. Simpson was inexorable: he had his bond, and the electric plant went back to Bombay. Whether or not the unhappy officials had to suffer we are not told.

Ship Lighting.—The new steamer *Halifax*, built and engined by the London and Glasgow Engineering and Iron Shipbuilding Company, went down the Clyde on her trial trip last Saturday. The *Halifax* has been built to the order of the Canada Atlantic Steamship Company, and is the pioneer boat of a line to ply in the passenger service between Charlottetown, Halifax and Boston. There are berths in all for 424 first class and 50 second class passengers. The steam-heating, lighting, ventilating, and sanitary arrangements are about as perfect as one could wish them to be, the electric light being used throughout the vessel, even to the cargo holds. Last Saturday afternoon Messrs. Napier and Sons launched from their shipbuilding yards at Govan a new steel screw steamer to the order of the Royal Mail Steam Packet Company, London. The *Atrato* is the first of two steamships for the company's Brazil and River Plate service. The accommodation for the passengers is of the most luxurious description, and all the details have been carefully considered with special reference to a first-class service in a hot climate. Messrs. Siemens, London, will provide a complete installation of electric lighting.

Electric Light Wires.—The strain of the Rochester District Electric Light Company's wires recently pulled down a chimney at Chatham, and did damage estimated at £50.

The United Telephone Company.—The *Financial News* says: Some important changes are being made in the staff of the United Telephone Company; but as Mr. Morgan of Liverpool is to be retained as managing director, they will not be of much benefit to the shareholders or the public. What is most needed is a competent London manager in Mr. Morgan's place.

The Paris Telegraph Operators.—Telegraphing on Monday night, the Paris correspondent of the *Daily News* says:—"The excitement which was manifested last night and this morning at the Central Telegraphic Office has calmed down. A number of Hughes apparatus got out of order at Lyons, Marseilles, Toulon, and Bordeaux, and so gave leisure to the discontented clerks and operators to parade their feelings. In the afternoon to-day new delegates elected by the clerks and operators held a meeting at which to discuss a circular letter inviting deputies and town councillors to a larger meeting that was to be held at the Salle Wagram. This move was met by the following Service order:—'The Director-General of Posts and Telegraphs reminds all those employed in his department that State functionaries can have no legal representatives other than their superiors. Every official who, after the promulgation of this order, defies this rule by taking the title of delegate, or any similar one, will for having done so be regarded as no longer in the Service.' A strike seemed imminent this morning when the day staff at the Central Office was going to relieve the night one This evening, however, the deranged Hughes apparatus are in many places set right, and communications are open. Amsterdam is, however, cut off. At one time to-day London and Berlin were also in the same position. A telegraph inspector assures me that the suspension of communication was due to the electrical state of the atmosphere."

The Telegraph in China.—It is announced that the telegraph convention between the Chinese Government and the companies owning cables in Chinese waters has been signed. The Chinese Government reserves to itself the right of cancelling the agreement in case the arrangement should be found to prejudicially affect the Chinese telegraph system.

Cable Rates for Press Messages.—The directors of the *South American Journal* are seeking public support in an effort they are making to procure a Press rate for telegraphic messages between Europe and South America. Similar concessions have been granted for nearly every part of the world. Thus the Press rate to the United States is only 5d. per word, whilst private messages pay 1s. To India the Press rate is 1s. 4d. against 4s. for private messages, and to Australia 2s. 9d. as against 9s. 4d.

Cable Repairs.—We learn that the ss. *Amber* has recently repaired the African Direct Company's sections Lagos-Accra and Brass-Bonny. This company seems to have experienced a great deal of trouble with its cables.

Breaking of an Atlantic Cable.—The Anglo-American Company's Brest-St. Pierre cable broke on Monday. This is the old 1868 cable, which was only repaired on the 28th of July last. It has always been a source of trouble and expense to the Anglo-American Company—in fact a new cable could have been laid with the money expended in repairs of this cable.

Electric Traction.—The experiments on electric traction on tramways commenced a short time since in Paris will be continued in a systematic manner on the Neuilly line with the Electric Power Storage Company's accumulators.

The Proposed Electric Tramway in the Isle of Wight.—At last week's meeting of the Newport Town Council Mr. Salter moved the resolution which has already been published in the ELECTRICAL REVIEW, relative to the condition under which the permission already accorded by the Corporation for the establishment of an electric tramway between Newport and Carisbrooke should become effective. He stated that the cost of the completion of the retaining wall from Upper Mall to Stile House, and the pitching of a water table (included in the conditions) would be about £240, which was in proportion to the length of the proposed line more than the Southampton company was paying. He considered that it would be unreasonable to insist upon an expenditure by the company of £100 in addition to that. On the other hand, the promoters of the new undertaking had written to him to say that they were willing to consent to the conditions which he was now proposing. There was every prospect of the tramway being made a success and a benefit to the inhabitants. Mr. Jordan seconded. Alderman Eldridge described the course taken by the motion as unnecessary and unwise, and said that while strongly in favour of the railway, he thought that they ought to take necessary precautions, seeing that their streets were to be interfered with. He moved, as an amendment, that the matter should be referred to a committee, to bring up a report at the next meeting. Sir Francis Pittis seconded, and eventually, on the suggestion of the mayor, Mr. Salter agreed to the amendment, which was thereupon carried without a division.

Brighton Electric Railway.—An incidental reference to the above was made at the Brighton Town Council last Thursday, when, on the foreshore question being discussed, it was urged by Mr. Weston that a part of the shore had practically been given up to the electric railway, which, to his surprise, he had learnt it was intended to extend. Mr. Berry said he had been informed by the Chairman of the Roads and Works Committee that there was no intention to bring forward the question of the electric railway again.

Electric Portable Battery and Gas Igniting Company.—We are informed by the General Electric Company, Limited, that Mr. G. Binswanger, in conjunction with some of his friends, has acquired the works, plant and patents of the Electric Portable Battery and Gas Igniting Company, Limited, of Salford, which company went into liquidation about a year ago. The Manchester works will be carried on under the style and title of "The Manchester Electric Works Company," and will be in a position to execute orders direct.

Cricket.—The members of the E.P.S. Cricket Club and friends, numbering in all about twenty, had a pleasant trip on Saturday from Millwall to Putney in the electric launch *Lady Cooper*. The object of the trip was to play the club's last match of the season, against the Vauxhall Distillery C.C. The match was a very exciting one, the E.P.S. winning by four runs, the last wicket of their opponents falling just as the clock struck the hour for drawing stumps.

Making the Gas Tank Sink.—Said a travelling man in the Palmer House, Chicago, in the hearing of a reporter: "I never order a fire in my room in a country hotel. I carry a warming apparatus along, which is both convenient and not costly to myself. "See?" and he pulled out a pair of nippers and a gas burner which would throw a flame at least seven inches wide. "It's this way," he continued; I register and go to my room. The burner is, of course, plugged with cotton, so that you can't get enough light to see to go to bed by. I yank it off with my nippers, screw on my patent appliance, and then sit by the window and watch the city gas tank sink down towards the ground while my room gets warm." Of course, there is a moral to this story. To hotel-keepers it is: Give up gas and take electric light.

A New Insulator.—The *Chronique Industrielle* describes a new insulating preparation, for which is claimed the properties of resisting heat and moisture without loss of insulation. It is composed of one part Greek pitch to two parts of burnt plaster (by weight). The mixture when hot is of a pasty consistency, and can be applied with a brush or cast in moulds. In some respects it is similar to ebonite, as it can be turned and polished.

Paris Exhibition of 1889.—The meeting of the International Congress of Electricians will take place during the early part of September, 1889. The committee of organisation has elected M. Mascart as president.

The Stratford-Manor Park Electric Motors.—We are informed by the Elieson Electric Company that the so-called breakdowns on the Stratford-Manor Park line have been nothing more than two or three incidental mishaps similar to those that occurred at the commencement of the last prolonged running, one being caused by the failure of a pair of wheels on which the trolley ran. The company is still at liberty to work when sufficient engines are ready to run the section.

The Dead and Gone.—"X. Y. Z." writes to the *Financial Critic*:—"Can any Electric Light Syndicate shareholder say what has become of the £3,000 capital subscribed for the purpose of buying Gümpel's patents, the amount being repayable to the syndicate members on the launching of the United Kingdom Electric Light and Power Company, Limited? In its stead the patents were sold to the Phœnix Electric Light and Power Company, Limited, and as far back as October 27th, 1882, it was fully expected that the delay arising in distributing the bonus earned by the syndicate would be of short duration. It is said about £2,500 was paid for the purchase of the patents, and that the primary cause of the delay was the failure of the Phœnix Company to perform the agreement entered into, and that £16,450 was the sum claimed for damages for breach of contract, and also a further sum was expected to be got from a Mr. Gümpel, in respect of some failure to perform some contract. Has ever any money been received, or when are these two claims going to be satisfied? Who is looking after the interests of the syndicate shareholders, and what steps are the shareholders going to take to guard their own interests? Has any money been received from the Phœnix Company for the patents, or has the Phœnix Company ever returned the patents to the syndicate? Who is the secretary or liquidator of the Phœnix Company? It is time the shareholders knew the position of affairs, so that they can unite together and take action if necessary."

Another correspondent writes to the same paper respecting the Electrical Appliances Syndicate, as follows:—"Perhaps some of your many readers can afford me information as to how much was subscribed to the above-named syndicate, and give me the names and present addresses of the directors and secretary? It seems the company was formed about November, 1882. Granville Ullathorne, of 1, Rutland Road, Hammersmith, and Samuel Crosse, of 49, Holland Road, Brixton, were two of the directors, and A. Moll was the acting secretary. The shares were issued as warrants to bearer. The capital of the company was £5,000. The first issue was 250 shares of £10 each, and was registered July 19th, 1882, under the Companies' Acts, 1862 to 1880. Has anyone a prospectus by them at the present time? What did the syndicate holders do with the patent rights? Where are the books? Has anybody ever seen a balance-sheet?"

Educational.—Some interesting notices relating to the City and Guilds of London Institute evening classes, the classes at the Glasgow and West of Scotland Technical College, Mason's College, Birmingham, and King's College, London, will be found on page 18 of our advertisement supplement.

The Sun Lamp.—We are pleased to hear that the electric "Sun" lamp is again to be placed upon the market in consequence of the improvements made by Mr. F. R. Boardman. It will be remembered by most of our readers that this lamp is different from ordinary arc lamps, as it consists of a block of Carrara marble placed between the carbon electrodes and the arc playing through the block makes the same incandescent, and produces a light as nearly approaching to sunlight as is possible by artificial means. Mr. Boardman's specification provides for the absolute automatic lighting of the lamp, and also for lamps being placed in parallel or series on alternating or continuous current circuits.

New Catalogue.—Messrs. Selig, Sonnenthal, & Co. have recently issued a supplement to their general catalogue giving particulars of a great variety of machine tools and engineers' requirements. In it are given a description and prices of the Sunderland silent gas or petroleum engine, which is stated to be the only gas or oil engine which effectually provides against leakage of gas or poisonous residuum into the apartment in which it is working. Several steam engines and boilers are also included, some of them being specially recommended for electric lighting purposes. Amongst the machine tools described is the "Victoria" quick-speed drilling machine, which, on account of its many advantages and great capacity, would be found useful in almost any workshop. Many other drilling machines are also included, as well as machines for boring, milling, planing, shaping, sawing, punching, shearing, and other purposes. On pages 180 to 184 (concluding the list) a number of braiding machines for covering telephone and telegraph wires are represented, and the prices given.

Finsbury Evening Classes.—It is not generally known that the evening classes at the Finsbury Technical College are attended by nearly 1,200 students, of whom no fewer than 560 are receiving instruction in electrical subjects. The numbers of entries during the last session were as follows:—Electrical technology, ordinary course (first year), 137; electrical technology (advanced), including lighting and transmission of power, 128; special laboratory class in electroplating, 13; special course on electric bells (lectures and laboratory work), 77; special short course on the mechanical principles involved in dynamo-electric machines, 205. The latter lectures were delivered by Prof. Perry, whilst those of ordinary courses and of the special course were by Prof. Silvanus Thompson, an occasional lecture being taken by the demonstrators, Mr. Robinson and Mr. O'Keeffe. The electroplating laboratory is under the instruction of Mr. Rousseau. Since the close of the last session there has been great activity in preparing for the coming session, which opens on October 1st. The lighting of several of the laboratories has been changed and improved, and the dynamo-room has been rearranged with a view to accommodating new machines. Amongst the special courses announced for the coming session are lectures on optical principles and practice; on springs and their application in instrument making; differential calculus as applied to mechanical and electrical engineering; and a laboratory class in electroplating and typing. The advanced course in electric lighting begins this autumn with Prof. Thompson's lectures on accumulators, followed later by arc lamps, glow lamps, and dynamo machines. It may be mentioned, in passing, that the "plant" employed in the college work now includes nine dynamos of various kinds, eight species of arc lamps, a complete set of electroplating baths, a small outfit for manufacturing incandescent lamps, besides motors, transformers, telegraphic apparatus, and the usual appliances for electric testing.

To Mr. William Brand.—A letter from Russia, addressed to Mr. William Brand, who wrote on electric traction in the REVIEW for June 8th last, lies at our office. If he will send his address the letter shall be forwarded to him.

Electric Light Fittings.—Messrs. B. Verity & Sons have just issued what is certainly the most comprehensive catalogue of electric fittings that we have seen, and we can easily understand that its production has involved an outlay of about £500, and that the designs have occupied the attention of the artist to the firm, Mr. S. Crichton Hannah, for many months. The price list forms a handsome book, bound in blue and gold, and the illustrations are reproduced by the phototype process. Prominence is given to such styles of smaller fittings as have been found in the large experience of the firm to meet with most general favour. The volume contains designs for fittings in a combination of copper and brass and of copper and silver, a large number of floral designs for work in brass, and also some for wrought iron. Ship fittings, large electroliers, fancy glass shades, and a number of special electrical sundries are also included.

Electro Therapeutics.—Dr. G. N. Stewart, Owens College, sent recently to the Royal Society of Edinburgh a preliminary communication on the electrolytic decomposition of proteids. He pointed out that it is an important question whether the conduction of electricity by animal tissues is mainly or entirely electrolytic. If it is mainly electrolytic, the further question becomes interesting, What are the electrolytes? The enquiry is thus brought into relation with the whole of electro-physiology on the one hand, and the whole of electro-therapeutics on the other, and, at the present moment, it gains special interest from the practical point of view in connection with the recent introduction of strong currents into gynæcological treatment. The investigation is as yet far from being complete, and Dr. Stewart is at present carrying on the experiments. In the case of egg-albumen it has been found that the resistance at any given temperature is not changed by coagulation, but that it is enormously increased by dialysis. The conclusion is that it is, mainly at any rate, by the electrolysis of the simple inorganic constituents that the current passes.

Maxim-Weston Electric Company. — Since the leaderette respecting this company on page 331 was written, we have received a copy of the directors' circular, accompanied by a report by Messrs. Boyce and Ramsay, chartered accountants, who were asked to investigate the accounts of the company. We are only able in the present issue to give a few of the paragraphs from the directors' statement. In alluding to the report of Messrs. Boyce and Ramsay, it says: "By this report it will be seen that the assets were stated in the balance sheet of 31st December, 1887, at about £17,445 in excess of their value, and that the results of the trading have not been truly stated in the past." Further on it says: "Notwithstanding the present unsatisfactory position of the company, the directors are strongly of opinion that with honest and attentive management, a good and profitable business may be carried on. . . . The directors therefore recommend that the capital of the company should be reduced by the cancellation of 2s. 6d. per share upon the existing 5s. shares, and that to provide working capital the 188,000 shares remaining unissued should be issued at 2s. 6d. each. With this object in view, the directors have convened an extraordinary general meeting of the shareholders, to be held on Wednesday, the 3rd October, 1888, to which the necessary propositions will be submitted."

NEW COMPANY REGISTERED.

Medical and Scientific Apparatus Company, Limited. Capital £1,000, in £1 shares. Object: To carry on the business of electricians and electro-depositors, manufacturers of and dealers in surgical, medical, philosophical, electrical and scientific instruments, appliances and apparatus. To acquire the provisional protection, date 17th May, 1888, No. 7,357, granted to T. P. Christopher Crampton for improvements in clinical thermometers, applicable also to other thermometers. Signatories (with 1 share each), J. A. White and E. J. De Barcotte, 38, Holborn Viaduct; F. E. Pearl, 37, St. George's Street, Peckham; A. E. Essinger, 11, Hatton Garden; F. Bruchy, Portsdown Road, N.W.; F. C. Rimmer, Manor Park, Streatham; J. White, 64, Myddleton Square, E.C. Registered 25th inst. by Messrs. White and De Barcotte, 38, Holborn Viaduct.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

London Battery Company, Limited.—At an extraordinary general meeting of this company, held on the 23rd ult. at 132, Southwark Street, the following special resolutions were duly passed, and at a meeting held on the 7th inst. were confirmed:—

"That Articles 70 and 72 of the company's articles of association be wholly expunged, and in lieu thereof the following articles shall be inserted":—

"Article 70.—The number of the directors shall not be more than seven nor less than two, not including in such number any person for the time being appointed managing director of the business of the company."

"Article 72.—The remuneration of every of the directors, other than the managing director, shall be at the rate of £50 per annum, with an additional £25 to the chairman of the company for the time being; and whenever the amounts appropriated to the payment of all the dividends, whether preferential or otherwise, declared in or for any year shall together reach an amount equal to 10 per cent. of the capital paid up or expressed to be paid up on all the shares in the company issued at the time of the declaration of the last of such dividends, the directors, including the managing director, shall be entitled to receive as further remuneration 10 per cent. of the balance of any further net profits actually declared as dividend during the like period as shall remain after the appropriation of a sufficient sum to pay the aforesaid dividends at the rate of 10 per cent., and such further remuneration shall be divided among them in such proportions and manner as the directors may determine."

These special resolutions were duly filed on the 13th inst.

The annual return of this company, made up to the 26th July, was filed on the 19th inst. The nominal capital is £10,000 in £5 shares. 539 shares have been taken up, and the full amount has been called thereon. The calls paid amount to £2,695. 480 shares, upon which no payment had been made, have been forfeited.

Railway and Domestic Electric Lighting Company, Limited.—The office of this company, formerly at 6, Great St. Helens, is removed to 34, Great St. Helens.

Automatic Electrical Corporation, Limited. — An agreement of 20th inst. (filed 22nd inst.) provides for the purchase by the company from Marcel Suppey, C.E., of Paris, of certain improvements recently invented for the manufacture of a new and improved galvanic battery, with apparatus for automatically supplying liquids (British letters patent dated November 5th, 1885, No. 13,422), and also certain improvements in self-acting electrical batteries or generators in which the liquids are automatically renewed; together with several foreign letters patent in connection therewith. The purchase consideration is £76,800, payable £75,000 in fully paid shares and the balance in 18 debentures for £100 each, forming part of an intended issue of £25,000, bearing 8 per cent. per annum interest.

Mayfield, Cobb, and Company, Limited (electrical apparatus manufacturers, &c.).—The statutory return of this company made up to June 19th was filed on July 9th. The nominal capital is £20,000, in £5 shares; 2,006 shares have been taken up, and the full amount has been called upon 776 shares, and upon 230 shares no call has been made. 1,000 shares are considered as fully paid. The calls received amount to £3,989, the sum of £80 remaining unpaid. Registered office, 35a, Queen Victoria Street.

E. T. Syndicate, Limited.—At a meeting of this company, held on the 14th inst., an account was given showing the manner in which the winding up of the company had been conducted and its property disposed of. The notice of this meeting having taken place is signed by Mr. F. M. H. Jones, of 1, Perren Street, Ryland Road, N.W., the liquidator of the company.

SHALLENBERGER'S ELECTRIC METER.*

SOME months ago, a new application of the alternating current in the production of rotary motion was made known almost simultaneously by two experimenters, Nikola Tesla and Galileo Ferraris, and the subject has attracted general attention from the fact that no commutator or connection of any kind with the armature was required. The principle has been very successfully applied by Mr. Tesla in the production of a practical motor, which is destined soon to occupy an important place among the growing number of electrical appliances depending upon alternating currents for their operation.

For some time previous to the publication of the results above referred to, Mr. O. B. Shallenberger, electrician of the Westinghouse Electric Company, had been at work on a series of experiments tending in the same direction, the results of which served as a basis for the construction of a meter depending on analogous principles, although applied in a way differing notably from anything described up to the present time by either of the investigators referred to. The meter was already completed in an experimental form at the time when the results of the experiments of Mr. Tesla and Mr. Ferraris were made known, and its thorough practicability was demonstrated, although for legal reasons it was unadvisable to make the fact known at that date.

Notwithstanding the urgent need of a meter wherever electric lighting has been carried on commercially, nothing has presented itself thus far that indicated any decided advance in this direction, until the advent of the instrument invented by Prof. Forbes, the great simplicity and beauty of which cannot be gainsaid. The one apparent difficulty in the way of its adoption seems to be its extreme delicacy and the necessarily minute accuracy in its manufacture and adjustment required to obtain satisfactory results.

It has been the desire of Mr. Shallenberger to produce a meter equally simple, but, if possible, more practicable in its nature, and requiring a less degree of skill on the part of the workmen in manufacturing; or in other words, something that could be made and used in a rough and ready way without diminishing its reliability.

This, it is thought, has now been accomplished, although the use of the instrument in its present form is limited to alternating currents. In this connection it may be observed that although a few years ago one of the objections raised against the use of alternating currents was the difficulty in measuring them in a practical way, the fact is that these difficulties have gradually disappeared until they are less important than in the use of direct currents.

The principle upon which the new meter operates may be understood from the following considerations. If an alternating current be made to traverse a coiled conductor in proximity to the two other conductors closed upon themselves, the secondary currents set up in these two conductors will correspond with each other to a greater or less extent in phase, and will be approximately in the same direction at the same instant, but both will differ in phase from the primary or inducing current. An attraction consequently takes place between the two secondary circuits, and if free to move, the conductors carrying these currents will be attracted to each other in a greater or less degree, depending on the amount of the primary current and on the displacement of phase between the primary and secondary currents. If one of these conductors be made fixed and the other movable, the motion will evidently be confined to one of the conductors, and if the action can be continued so as to produce the attraction always in the same direction, a continuous rotary motion may be obtained by the inductive action solely, and without any direct communication with the source of current. The discovery of this principle suggested at once the practicability of applying it to the operation of a meter since it is only necessary to produce a rotary effort or torque in some simple and reliable way, bearing a definite relation to the current that produces it, in order to have a perfectly accurate means for measuring such current.

With this end in view a number of experiments were made, which it is unnecessary to follow here, presenting a great variety of effects depending in a general way upon the principle referred to, and leading eventually to the form of meter here described.

It was found that one of the conductors might be replaced by a core of iron, inasmuch as the mutual attraction between the iron core and the coil would be made to serve in place of the attraction between the two secondary coils, and with greater effect so long as proper relations were maintained to carry out the same mode of operation. If a disc of iron be surrounded by a copper band, and this with another conductor at an inclination to the first, the passage of a current through the outer coil will, by the action of the secondary currents set up in the short-circuited coil, produce a rotation of the disc; and the torque exerted is approximately proportional to the square of the current, so long as the rate of alternation is maintained, approximately constant.

Referring to the diagram, fig. 1, *a* is a flat ring of soft wrought iron, mounted on a light disc of brass or aluminium, rigidly attached to a slender steel shaft.

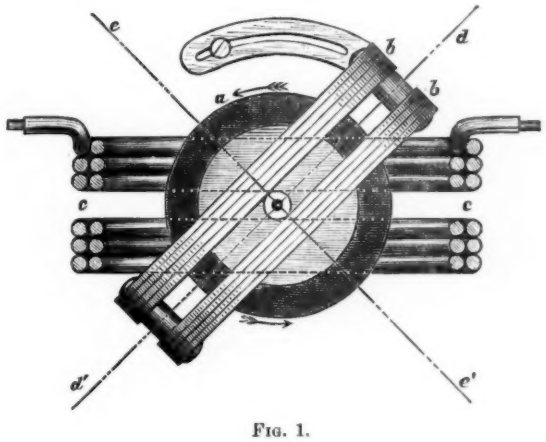


FIG. 1.

b, *b*, are copper plates punched in the form of a flattened oval and riveted together at the ends, placed so as to surround the disc closely without touching it. These are adjustable in position with respect to the coil, *c*, *c*, which surrounds the whole. When in the position shown, the rotation of the disc is in the direction of the arrows, and the torque is greatest when the plane of the coil shown by the line, *d*, *d'*, is at an angle of 45° to that of the coil, *c*, *c*. If while the current is passing through the coil the position of the plates, *b*, *b*, is changed gradually to *e*, *e'*, the speed of rotation of the disc diminishes until an angle of 90° is reached, and beyond this the direction of rotation reverses, reaching maximum speed again at 45° on the opposite side.

In applying this to the meter, only a few degrees movement of the secondary conductors, *b*, *b*, is required for the necessary adjustment.

This arrangement was selected from a large number

* From the New York *Electrical Engineer*.

of others because of its ease of construction, the small self-induction it introduces, and its ease of adjustment.

The maximum torque is exhibited at an angle between the coils of 45°, while at 0° and 90° it disappears altogether. When the angle is 0° the coils being parallel have a maximum mutual induction, but no torque is exerted; and at 90° no current is induced in the

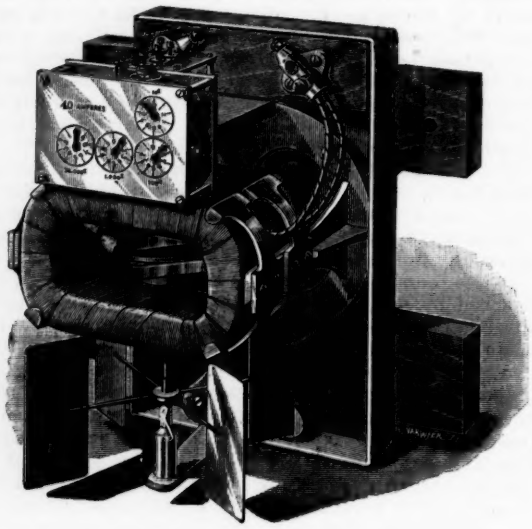


FIG. 2.—SHALLENBERGER'S METER (*case removed*).

secondary coil, and consequently there can be no torque in that position.

In order that the speed of the disc may be proportional to the current, it is necessary that some resistance be offered to its motion, which bears the same relation to the speed as that of the torque to the current, and the simplest means of doing this is to attach to the same shaft on which the disc is carried a suitable number of light vanes, whose motion is opposed by the resistance of the air as the disc revolves. This resistance is found to vary almost exactly in the proper ratio, and consequently the revolution of the disc is as nearly as possible proportional to the strength of the current. The rotations of the disc are counted by a train of wheels connected with an indicator similar to that used for gas meters, and showing ampère hours. The accuracy of the instrument is affected slightly by changes in the rate of alternation of the current; but since in practical electric lighting the rate of alternation is maintained nearly constant, the error due to this cause is quite insignificant, being less than proportional to the number of alternations. The adjustment to the exact speed required is made by changing the angle of the secondary coil; but in practice the instrument is made very nearly correct as it leaves the factory, requiring only slight correction.

TEST OF 40 AMPEREMETER.

Current in amperes.	Reading of meter.	Percentage of error.
2·06	1·6	
4·02	4·07	+ 1·2
5·00	4·95	− 1·0
9·9	10·02	+ 1·2
15·0	15·1	+ 0·7
20·0	20·0	0·0
29·7	30·0	+ 1·0
37·0	37·0	− 1·1
49·3	Overloaded. 45·4	− 7·9

The accompanying chart and table show the operation of a 40 ampère meter, with currents varying from the smallest capable of turning the vanes, and overcoming the slight friction of the bearings, to an overload of 25 per cent. Currents are measured on the horizontal line, and the corresponding readings of the meter are shown by the vertical distances. It will be seen that the departure from the theoretical straight line representing the mean performance of the meter is very slight, and in no case within the working limits reaches two per cent., except at starting point; while at 25 per cent. overload the proportional rate only falls off 7·9 per cent.

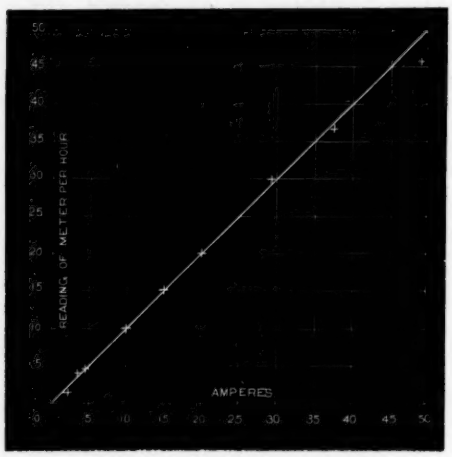


FIG. 3.—TEST OF SHALLENBERGER'S METER.

The ease with which this meter may be adapted to circuits of different capacity is obvious. By interposing between the meter and the circuit to be measured a small converter, the current may be reduced or increased in any ratio, and since the energy transformed by such converter is only the amount required in operating the meter, namely, about one-eighth of one per cent. of the energy measured, the dimensions of the converter may be very small, and consequently but very little is added to the cost of the simple meter. By changing the ratio of this converter any capacity may be given to the meter, so that the same instrument may be used to measure 10 lights or 10,000 lights within the same percentage of accuracy and without change in its construction.

There is, however, one feature worthy of notice in this connection, namely, the point at which the meter will begin to turn, or, in other words, the percentage of its full load at which the registering of the current begins. This, in the 40 ampère meter already mentioned, is 1½ ampéres, or say three per cent. of the rated capacity. While this represents only one or two lamps on a 40 ampère meter, and only one lamp on a 20 ampère meter, it will be seen at once that on a meter for 1,000 lamps the same proportion would give 30 lights required to start the counter.

In order to overcome this difficulty, for the larger sizes of meters a shunt coil is provided, which, with a current almost inappreciable in amount, charges the inducing coil of the meter to a degree sufficient barely to overcome the inertia and friction of the vanes, and in this way the large meter may be made to start on less than one per cent. of its full load as easily as the small meters start on three per cent.

There are certain cases in which it is very desirable, even where a large number of lights are installed, to measure a comparatively small proportion of the total current. Lamps are sometimes used for watch lights and other purposes, while the main body of the lamps are or are not in operation, and it is for this reason that the shunt coil is applied. Its operation may be made as sensitive as the conditions require.

The greater simplicity of the meter having a direct coil only, both in its construction and connection in the circuits, makes it preferable not to employ the shunt coil on any of the smaller sizes, namely, below 40 ampères. But it is evident that in special caces where

it is desired to measure accurately the widest possible range of current the shunt coil can be employed with advantage.

Practical tests have shown this meter to be thoroughly reliable in its action, and with the exception of some minor details in the construction, no serious difficulties have presented themselves at any time. The meter as now manufactured for practical use seems to fill the requirements very satisfactorily, and has given no cause to doubt its entire reliability within limits of error much smaller than have hitherto been obtained in ammeters, voltmeters, and similar instruments.

LIGHTNING CONDUCTORS.

(*Continued from page* 323.)

PROF. OLIVER J. LODGE said: I must confess that I have had nothing whatever like the experience of Mr. Preece to base my statements upon. So far from having half a million lightning conductors under my supervision, I have not even one. I have not one to my own house, nor is there one to the college in Liverpool with which I am associated. I have suggested to the authorities to put one up, but lightning conductors seem at present to be so expensive, that the answer one frequently gets is that it is cheaper to insure. I rather think there is some fallacy in the argument, which ought to be treated in Section F, that because an insurance company agrees to pay for damage to a house, it is therefore nobody's business to protect it. I do not know where the fallacy is; but I feel sure there is one. Nevertheless, manufacturers often go on that principle.

It is perfectly true, as Mr. Preece says, that if my views are correct, very few buildings are effectively and thoroughly protected at the present time. It is also true that if they are correct, lightning conductors will in future be bought for—I was going to say as many shillings as they now cost pounds; at any rate, they will become excessively much cheaper, and that of itself will be no slight advantage, provided, of course, they are equally effective.

Mr. Preece has poked some fun at the mathematicians, but as I can hardly pretend to be a mathematician in this room, I shall of course say nothing about that; it is quite unnecessary. At the same time I am quite willing to argue the point without any introduction of mathematics, without a single symbol, I hope. As far as the term self-induction is concerned, if electro-magnetic inertia is preferred, I have not the slightest objection to calling it that. It is a very good term; the only objection is one of possible caution, that it may seem to imply a little more than we certainly know. For myself, I feel that we shall be quite certain, sooner or later, that self-induction is due to inertia, material inertia, inertia of ether, if we may so say. In using the term electro-magnetic inertia, we might seem to imply a knowledge which we do not certainly possess at present. When we do possess it we shall be a great deal further on toward the statement that electricity is a form of matter. I do not think Mr. Preece recognises how near he goes, when he speaks of electro-magnetic inertia, to the assertion that electricity is a form of matter. His argument is that electricity is a form of energy, because you can buy and sell it. As well argue that sugar is a form of energy because you can buy and sell it. Then he said electricity was not a form of matter because you can make it do work. A hydraulic engineer might as well say that water is not a form of matter, because with water you can do work.

Now, Mr. Preece began by saying that there is no authentic case on record of a properly constructed conductor failing to do its duty. Well, I have read carefully the report of the lightning rod conference to which he drew attention, and there I find enunciated a large number of entire failures. One noteworthy case, which is often quoted, is that of a brass rod an inch thick on a steeple in Italy; this rod was smashed to pieces and the spire was destroyed, the flash being seen by a number of people. There are a number of other cases. In my lectures this spring I quoted as the best protected building in the world the Hotel de Ville in Brussels, on which M. Melsens has spent so much time and trouble. It is elaborately protected by innumerable conductors, by admirable earths made in a variety of ways, it bristles with points all over the top, everything carried out in the most approved style regardless of expense. But in the month of June that building was struck by lightning and set on fire. The fire was put out. The particulars of that case ought to be published because that is a building the protection of which has had books written about it; M. Melsens himself wrote a book about it; and it would be very instructive when a thoroughly protected building was struck to find out all about it, what damage was done, and how, and why. I really do not think, although I speak from a limited experience, except from reading, that it can be seriously held that existing conductors never fail.

Then Mr. Preece had a hit at me in which, I admit, he had the advantage. It is where he quotes a sort of Midlothian speech of mine in which I made an entirely erroneous statement. But he must not adduce that as a statement of a mathematical calculation, it was the merest parenthesis thrown in, and was very hastily done. One ought not to do those things, but if one writes much one is very apt sometimes to make these hasty statements. The history of the matter is instructive, because this must be a condition of mind through which so many people have gone. When the Society of Arts asked me to give the lecture I thought, "Yes; I will tell them about self-induction," because I knew that the Lightning Rod Conference had not drawn attention to that. I happened to be writing something on the same subject, I think in *Nature*, and I noticed that the magnetic permeability of the material came in squared, so I was going to tell them that though iron was cheaper, was more difficult to melt, had a higher specific heat, and in a variety of ways was better than copper, yet as regards magnetic inertia it was enormously worse. But before actually giving those lectures I made a few experiments on this point, especially the one here quoted, and, to my surprise, I found that so far from iron being worse than copper it was often rather better, that even a thin wire of iron carried off the discharge better than a thick wire of copper. This experiment naturally, and at once, effected the conversion which Mr. Preece deplores.

I am not quite sure that I understood Mr. Preece, but in so far as I did understand him I do not think he was quite correct. I do not care about the A spark. The alternative conductor may be iron or copper, or any other metal, of any thickness you may wish to experiment upon. The top part of Mr. Preece's diagram is of no interest—or, at least, we need not attend to it now. The bottom part is. The B spark measures the E.M.F. which drives the current through the alternative path. You may adjust the B spark until the flash produced does not know which way to go, whether through the wire or through the air. Half the sparks fail when that is attained. With a spark micrometer at B you measure the distance between them when the E.M.F. is just on the verge of succeeding in driving the contents of the jar through the wire. I tried first a copper wire and then a thin iron wire of the same length, and I found that a greater distance of spark—a greater E.M.F.—was needed to drive the contents of the jar through the thick copper wire than through the thin iron one. Now, whatever explanation may be given of an experiment of that kind, a direct intimation from heaven could be no clearer. For some reason or other the copper and the iron are at least equally good. I do not press the point that iron is better than copper. I have never said that copper has more self-induction than iron; that would be a mad thing to say, but it may happen, for some reason or other, that the copper obstructs the current more than iron, but I prefer to say that they are just equal.

Mr. Preece said that when the Society of Arts asked me to bless the Lightning Rod Conference I turned out

a Balaam. But the Society of Arts did not ask me to bless the Conference, it asked me to give a lecture on lightning conductors, so there was no breach of contract. There were three parties to the little drama—Balak, Balaam, and the ass. Balak was the person who asked the prophet to come and give a lecture—Balak, therefore, is the Society of Arts, or say Mr. Trueman Wood; Balaam was the prophet who went and said what he ought to have said. I do not know who the third party is, unless . . . (Laughter)—unless it is the party who spoke against the prophet.

Now, Mr. Preece said that the function of a lightning conductor is to prevent a flash from striking the conductor. That is to say, that a lightning conductor ought never to be struck, or it fails. But they are struck, because they get melted. Yet, at the beginning of the sentence he said they never failed. I do not know which statement is to be taken as correct. If a lightning conductor can prevent a flash from occurring by its point action, well and good. But I have shown in these lectures that there are cases when a point has no protective action whatever; when a point can be struck by a thick and heavy flash just as readily as a knob. There are other cases where a point acts with a brush or fizz, and neutralises the electric charge without a flash. So a lightning rod has two functions, one to act as a point and prevent a flash if it can, and one to carry off the flash when it cannot help receiving it. We must remember that an electric charge has a certain amount of energy, and that has to be dissipated somehow; you cannot hocus-pocus energy out of existence by saying you will conduct a charge down to earth. The quicker you try, the more surging momentum you are likely to get. It may be better to let it trickle down slowly through a moderately bad conductor than to rush it down with great vehemence through a good conductor.

Concerning the length of flashes, I wish I had any information, but I have not. It is one of those things the meteorologist must determine for us. It is a very important thing to know. I have seen it stated that they are a mile long or more: Mr. Preece says they are only about 500 feet long. It is a matter of fact, and can be investigated; I have no first-hand, direct information.

As to whether the length of spark is proportional to distance: I would say that the experiment with oscillating currents to which Mr. Preece referred, and to which he was magnanimous enough to call my attention yesterday, were conducted with alternating transformers between points. Now, the area of cloud and the area of earth below it are not points, but flat surfaces, like the coats of a Leyden jar. In the case of the transformers the law did not seem to hold; but then it ought not to hold, so that will be all right. But between flat surfaces it ought. At the same time, if there are points on the earth's surface which are big and effective enough to act as points, it will not hold. However, the laws concerning discharge in dielectrics are well-known, and are scarcely matters for argument. But the circumstances of the oscillating current do not apply as regards the length of spark, for until the discharge occurs there is no oscillation; it is a mere static charge. The earth and the cloud above it are exactly like the coats of a Leyden jar which are preparing to spark into one another, and which do spark into one another when the difference of potential rises to a certain maximum; and the air between is then broken down.

Concerning the duration of flashes, that is a point again on which much valuable work may be done by meteorologists and photographers. I have seen flashes which certainly appeared to last one or two seconds. I cannot imagine that it is one flash that is doing that, but a series of multiple flashes succeeding each other very rapidly. If they could be proved to last long that would be an argument that they are not oscillatory. The fact that they deflect a compass needle does not prove anything concerning their duration, because a ballistic galvanometer is deflected by a momentary kick; a momentary blow given to a thing can deflect it, the blow having ceased long before the motion has ceased.

Another thing Mr. Preece adverted to was, the magnetising power of the flash, and that I think is the strongest point he adduced. A flash magnetises steel bars and deranges the magnetism of a ship's compass, and otherwise conspicuously produces magnetic effects. Now, an oscillating current one would think ought not to produce these effects. An oscillating current with a decaying amplitude is used by Prof. Ewing to demagnetise steel, not to magnetise it. A lightning flash is a gradually decaying vibration. Now, that will demagnetise things and ought not to magnetise them. It does magnetise them; therefore, how can it be a current of this kind? But the same difficulty is felt with a Leyden jar discharge, which is certainly oscillatory, because its sparks have been analysed by looking at them in a revolving mirror; and yet it magnetises needles. I do not fully understand that point, and I hope Lord Rayleigh will say something about it.

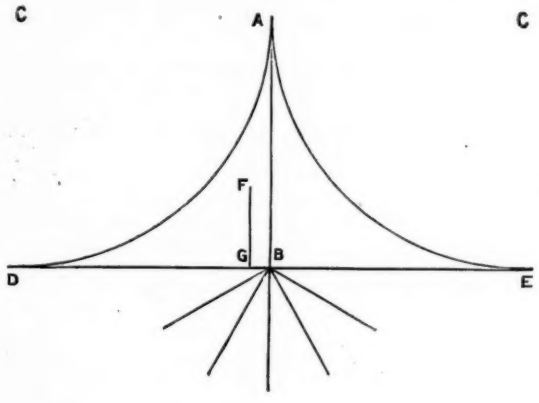
Mr. Preece was quite right in saying that the whole theory depends on these oscillations. What I have done, as far as the theory is concerned, is simply to call attention to these oscillations, which were well known in the case of Leyden jar discharges, and to point out that they applied also to lightning, which I think had not been noticed. The way in which they work is this: you have in a pendulum an analogue of them; raising the pendulum represents the charging of the jar—charge it more and more, and then discharge it—that is, you let it go. Now, when you let a thing go it naturally swings before coming to rest. It need not—it may meet with too much friction. Supposing this pendulum were raised and dropped in treacle, it might have a dead-beat motion down. A condenser may discharge through a leak, in which case it will empty very slowly. Those are cases in which there is no oscillation, but it depends entirely on the friction, the viscosity it meets with. If the friction is very great, like a leak, it goes down with no oscillation. But if there is no friction there must be oscillation. But inertia you must have, too. Mr. Preece admits the inertia. Suppose a Leyden jar going to spark; it possesses potential energy like a raised pendulum or bent spring—the instant it sparks a current rushes round. You have then a circular current, which, it is well known, will deflect compass needles and produce magnetic effects. That is the electro-kinetic inertia—represented by the ordinary inertia of the spring or pendulum when it passes the middle position. You have, first, a static charge; then, while it is flying past, you have a current and magnetic effects, and a kinetic energy, which carries it on to its other extreme position of static charge; and so you have these oscillations gradually dying out on account of friction. One interesting point is that if you make this oscillate in water instead of treacle, it will not prevent it from oscillating, but the oscillations will die out more quickly than if they took place in air. They would die out for two reasons; partly because of friction, which generates heat, partly because of the production of waves. The surface of the water would be disturbed, and waves would travel along; part of the energy would go in heat, and part in waves—that is, producing radiation, or we might call it light, if it were quick enough to affect the retina.

What the energy of a lightning flash is I do not know. I wish there was some means of determining it. It would be very important in determining whether lightning is likely to be oscillating or not; it is a matter of the resistance or friction compared with the inertia and the capacity which is discharged. The smaller the capacity the more likely it is to be oscillatory; the bigger the electro-magnetic inertia the more likely it is to be oscillatory. Now, the capacity discharged in a flash, I say, is small; and I say it for this reason, that the quantity of electricity discharged is well known to be small. The quantity of electricity existing in the portion of cloud discharged is a small quantity, but the potential of it is enormous. It is able to spark 500 feet, possibly a mile. That means an enormous potential. When a small quantity

is raised to an enormous potential the capacity cannot be great, for the capacity is the ratio of the two. There is no reason for supposing that the capacity discharged in a lightning flash is any bigger than that of a Leyden jar. We may have some means now of measuring the wave length of a lightning flash after the manner of Hertz. I may mention as a matter of interest that the radiation of the waves produced by a microforad condenser discharged through a coil of one secohm, as Profs. Ayrton and Perry call it—I prefer to call it a quad—the waves produced by that discharge, if it is oscillatory—ether waves—waves of light, will be 1,200 miles long. But you have nothing like that capacity in a Leyden jar, or in a thunder-cloud, the capacity discharged in the latter case I have guessed at as 10 metres electro-static units.

Mr. Preece has said he will supply me with covered wire to repeat these experiments on the alternative path. That is another instance of his magnanimity, of which I shall have great pleasure in taking advantage, and Mr. Preece may expect on his return to London to have a letter reminding him of his promise, for I may perhaps want large quantities of covered wire for this purpose.

Finally, there is the theory of the protection of area. Mr. Preece says :—"If it does not protect an area what is the good of it?" That is not an argument that it does protect an area. Now I know Mr. Preece's theory about the protection of areas, because he has published it in the *Philosophical Magazine*. But the area Mr. Preece protects is so extremely small that I think we might give it him without much argument. I will just show you what it is. (Diagram.) Suppose A B is the



lightning conductor, and D E the ground; take a bit of the ground equal to the height of the lightning conductor —a base line equal to that height—then you take a point at the other corner of the square, and then you describe a circle with this point, C, as centre, and, of course, you do the same thing on the other side. Now, the protected area, if you please, is this—A D E. Well, that is not much. If you apply that to every point of the house, you will find you want a lightning rod at every point. But Mr. Preece means that you must take the rod up to a gigantic height so as to bring the house within the protected area. Even then you will not be safe.

Why do I object to such a bit of protection as that? I object to it mostly because areas of protection draw one's attention to side issues, to a thing which it is better not to think about, because there is no certain area of protection, as one can show in this way. Take another rod (F G.) completely enclosed in this area of protection, and bring it up near to the lightning conductor so as to leave a little sparking space. Now, that rod, if area of protection has any meaning, ought to be protected; but I say that when a lightning flash strikes that conductor—this is mere assertion—you most likely will get a spark down to this shorter rod, which will take its share in helping to convey the current; therefore, it is not protected. If a man holds a lightning conductor when the flash passes down it he will most likely be killed, and if it passes through gunpowder—well, I don't know about gunpowder, because that gets blown about. It does not matter about the earth: let the conductor, A B, have a good earth and the rod, F G, a bad earth, still the same effect is likely to occur; a spark is likely to occur if the distance be too great.

I say that is so, because I have made experiments in the laboratory after this fashion. I take a rod a yard long and of any thickness, put it in the circuit of a Leyden jar discharge and send the discharge through the rod; this was a solid rod of copper. I then take a Wollaston platinum wire, or any other wire, as fine as possible, to make the contrast greater, and arrange it as a kind of tapping circuit, so that we will say the bottom end shall be in contact with the rod and the top end $\frac{1}{8}$th or $\frac{1}{16}$th of an inch away. Now, there you have a splendid conductor, better than any lightning conductor ever was. You have no trouble about earth, for you have a little tapping circuit close to it—the Wollaston wire, which you can hardly see. It seems absurd for a flash to jump across this $\frac{1}{16}$th of an inch and make use of this little wire; nevertheless a portion does, and for every flash through the conductor a side flash goes through the platinum wire.

I do not know that I have taken all the points raised by Mr. Preece, but I am sure I have taken enough for your patience, but I will merely say that there is one point on which he might have attacked me where he did not make out the full strength of his case, namely, the question, What are the conditions of lightning? I have assumed that flashes behave like the discharge of condensers in a laboratory; but it is a question whether cloud discharges are of this kind; you see a cloud is not like a mass of tinfoil well connected up, but consists of a lot of globules of water separated from one another by inter-spaces of air. It is more like a spangled jar, and you have no guarantee that such a jar discharges itself right out. It may be that you have first a bit of a discharge, then another bit, and so on, so that you may have a kind of dribbling of the charge out of it, and may fail to get these oscillatory and sudden rushes. At the same time I do not think that you can always guarantee doing this with cloud discharges, and it would not be safe in arranging protectors to protect for only one case, and that the easiest; you must provide for the possibility of sudden and violent discharges. Still the conditions of lightning are to be determined by observing lightning and not by experiments in the laboratory.

There are many other known points to which attention might be called, and which would have application in practice. Thus we have the momentum of one spark exciting others, and so giving rise to multiple flashes. Mr. Abercromby has a photograph here where the flash is breaking the air down in all directions at once. There seems to be a kind of rot set in in the air; one flash begins and the whole region smashes up in all directions. There is a point again to which attention is now for the first time drawn, and that is the application of the result of Hertz on the effect of the light of one spark in assisting others to form. The spark of an induction coil here will be able to start the spark of another induction coil up in the gallery merely by its light; if it is closer it will do it better, but it will do it at considerable distances. When we consider the brightness of a lightning flash it will be seen that this effect must have an important significance. There is no doubt that when once a spark occurs the light of it must cause all the air in the neighbourhood to be very easily broken down, and so may give rise to a multiplicity of flashes from all the neighbouring points. That is why I say the idea of areas of protections is very misleading. If one flash causes a number of others you had better not have the one, if you can help it. Therefore, I say do not run up these long rods to precipitate flashes near powder magazines and other similar places. If there must be one, be very careful indeed to have all the other conductors arranged so that sparks along them do not matter, because if one flash occurs you are very likely to get others.

Mr. Glazebrook asks me to describe the effect of light in producing a spark; but there is nothing in it. You want two induction coils only. Take a common induction coil and separate its terminals until they just cannot spark into one another; let the coil be working, but let the sparks just fail to pass. Light a piece of magnesium wire and they will instantly begin to go; take the magnesium wire away and they will stop. Instead of magnesium wire have another coil or a Holtz machine, or anything else, to make the light. Let one be just on the verge of sparking, and let another instrument in another part of the room begin sparking; if the light of that spark can fall upon the space between the terminals of the first, especially upon the cathode of this space, these sparks will begin to pass, too. The light of a spark, or ultra-violet light generally, seems to make air conductive; or, to speak more correctly, it seems to break down the transition resistance of air, especially on the surface of the cathode.

The Hon. RALPH ABERCROMBY said: I wish to contribute to the discussion some facts bearing on the subject that have been discovered by means of about 90 photographs of lightning flashes, collected by a committee of the Royal Meteorological Society, to which I have acted as secretary, and a few of the more remarkable of which I have brought for your inspection. In doing so I propose to confine myself entirely to such facts as bear on the discussion. The first point is, Is there any evidence in a photograph as to the passage of successive flashes along the same path? I think the answer is that there is no certain evidence. Sometimes there is an undoubted tendency of flashes to follow nearly the same path, though at other times the lightning flies irregularly all over the field of view. In some pictures the streaks of light are exactly parallel, but this effect is almost certainly due to duplication by optical defects. (2) An inveterate tendency of flashes to ramify, or to send offshoots from the main branch, is one of the commonest features revealed by photography. Numberless eccentricities of lightning are reported when buildings are struck; but nothing can be more irregular than the course of some of the flashes exhibited. The same tendency to fly off is found in the discharge of powerful electrical machines. I think some of this irregularity may be due to electric discharge through rain, and that it will be worth while to note, when damage is recorded, whether it is raining or not. (3) The flash is not always so instantaneous as is sometimes supposed. Flashes sometimes meander in such a manner that it is impossible to suppose the discharge can zigzag and turn in loops except in a very appreciable length of time. There is nothing out of the way in such a conception, for besides practically instantaneous flashes, there is the well known globular discharge which moves no quicker than a cricket ball, and it is inconceivable that there are not intermediate rates of discharge. It is well known that the photographs of many lightning flashes exhibit a ribboned structure, and it has been suggested that this appearance may be due to shaking of the camera, and evidence thereby obtained of a not very rapid discharge. Some of the pictures exhibited prove, however, that ribbon structure is not due to shaking. I cannot venture to say anything about the practical application of these facts, but believe that Dr. O. Lodge has materially contributed to the protection of buildings by calling attention to the defects of the systems at present in vogue.

It may, perhaps, interest the meeting to know that the scheme for the systematic observation of British thunderstorms, which I sketched before the Association at Manchester, is now working. The large amount of material which has already been collected has not yet been discussed, but I hope to discover, among other things, whether, as in Norway, certain classes of thunderstorms are much more destructive to buildings than others. I think 500 feet for the height of a thundercloud, as mentioned by Mr. Preece, is exceptionally low; but many are not more than 1,000 or 1,500 feet high, and by far the greatest proportion of lightning discharges take place at an altitude under 10,000 feet. (*To be continued.*)

THE TELEPHONE IN FRANCE.

THE Director-General of Posts and Telegraphs has just addressed to the superior agents of his department, a circular in which he sets forth the system which is about to be put in force to generalise the use of the telephone. The telephone lines are of two kinds: the inter-urban lines, which place towns in communication, and the urban lines, which serve for the use of the inhabitants of the same locality. The inter-urban lines, the establishment of which will be very costly, will be established at the expense of the State and as Budget resources. The urban lines, on the contrary, are easy to establish, and their working assumes a yield largely remunerative in all centres where they supply a real want. At present the number of urban wires in France is only 27. France is worse off in that respect than several other countries. Eleven of these urban lines have been conceded to the General Telephone Company; sixteen are worked directly by the State. By an agreement, dated November 15th, 1886, the Minister of Posts and Telegraphs conceded to the Telephone Company for 35 years the working of all the urban telephone lines in existence or to be established. This agreement will not become definitive till it receives the approval of the Chambers; but as it is not possible to foresee when that approval will be given or if it will be, the Administration has set itself to seek a combination which, while leaving the monopoly intact, should be of a character to remedy, as far as concerns the extension of telephones, the inconvenience resulting from the prolonged maintenance of the uncertainty at present prevailing as to the method of working to be adopted. According to the terms of the regulations at present in force, the subscribers pay, on the urban lines, in addition to installation expenses, a contributory share of 150 francs per kilometre of wire they use, and a subscription of 200 francs. In all towns in which the request is made, the Adminstration will give an estimate for the establishment of a telephone line as well as for its working till 1890.

It will make known the amount to the municipality interested, and if that municipality cares to go to that expense, the State will construct the line. The State will then delegate to the town the collection of the subscribers' fees. By the agreement now submitted to the Chambers, the State engages itself to cede to a company the right of farming the working of the lines which it works directly. In the case of this agreement being ratified, the State is to arrive at an understanding with the municipalities as to the conditions of the repayment of the remainder of the account. In setting forth this system, the Director-General of Posts and Telegraphs invites his agents to make inquiries as to the views of the municipalities and to endeavour to secure their adhesion. The municipalities which appear favourable to a line of telephone are to point out the inhabitants who wish to use it. Satisfaction cannot but be expressed at seeing the French Government occupying itself in bringing about the disappearance of one of the principal obstacles to the extension of the telephone. It seems to be the general opinion in France, however, that if the State wishes to keep the monopoly, it should say so; if it does not wish to run any risk and if it prefers to let the concession to a company to farm, it should make known its intentions. Commenting generally on the matter, a Parisian contemporary says: "The question is sufficiently ripe for a solution once for all. The General Telephone Company has obtained a precarious concession for Paris and some other places; but it cannot remove from the centre where it has installed its lines. Instead of satisfying the need of commerce and industry, our famous offices study combinations which, without taking into account the public interest, only aim at downright monopoly, while everywhere telephony is developing, thanks to the intelligent initiative of the State or of private companies, to which the necessary facilities have been accorded.

"That the system proposed by the Direction of Posts

and Telegraphs has the pretension of safeguarding the decision of Parliament, the interests of towns, and engagements entered into previously, we have no doubt; but that it accelerates the installation of urban telephone lines is another question. The intervention of deputies and senators, without counting municipal councillors, will multiply enquiries, delays, and difficulties of all kinds, and will subordinate industrial enterprises to considerations of a purely political nature. As the provisional loses its rights with difficulty with us, there will always be a complement of indispensable reports, and years will elapse between the deposit and the final adoption of the measure. In conclusion, from whatever side it be examined, and for many reasons easily perceivable, the system proposed by the Direction of Posts and Telegraphs appears to us as unacceptable as impracticable."

ON THE USE OF ELECTRICITY IN DISEASES OF THE THROAT.*

By JOHN MACINTYRE, M.B.,
Assistant-Surgeon Glasgow Royal Infirmary.

[A TABLE was exhibited, worked partly by secondary and partly by bichromate cells. In the circuit for heating and lighting were placed:—1. Contact breaker; 2. Nussbaum's resistance; 3. Switch for four incandescent lamps and one head lamp; 4. Resistance coil for these; 5. Fuse to prevent breakage of lamps. In the second circuit there were:—1. Hirschmann's galvanometer rheostat and reverser; 2. Alternating machine and continuous current transformer; 3. Arrangements for giving constant or alternate currents with the same wire.]

The switch table exhibited at this section is intended to show the apparatus required in the treatment of all affections of the throat by electricity.

As in other branches of surgery, we require the electric current for three purposes: first, the illumination of the cavities, although this is not yet universally employed; secondly, the heating of metals, such as platinum, for cautery purposes; lastly, the application of constant and alternate currents in nervous and muscular lesions.

Taking first into consideration the illumination of the cavities, it might be argued that the ordinary oil and gas light are quite sufficient for our purpose. In fact, in illuminating the cavities of the body, a broad distinction should be drawn between those cavities, such as the bladder, which can only be illuminated by means of an incandescent lamp, and others, such as the throat and nose, which can be quite well seen by reflected light from whatever source.

The last-mentioned can be illuminated by the electric light in three ways: first, by means of an electric lamp taking the place of the ordinary gas, and using the mirror on the forehead, but the incandescent carbon filament is exceedingly trying to the eye of the observer; secondly, the light may be placed on the forehead after Trouve's method; thirdly, by placing the light inside the cavity to be examined. The advantages of illuminating by an incandescent lamp are certainly great, and were pointed out by the writer in the *Glasgow Medical Journal* in January, 1885, and also by our President, Dr. Semon, in the *Lancet* a few weeks later. By means of the incandescent lamp one can obtain a clear white light, with simple portable arrangements, and at the same time allow of an examination of the patient in any position. This method has some disadvantages, inasmuch as secondary cells require attention, and primary batteries give some trouble; and, moreover, the lamps are rarely well made, and therefore do not last long. The use of the galvano-cautery is now so universal that nothing need be said with regard to its place as a surgical instrument, the only consideration for us now being the best methods of producing the current, and the improvement of the apparatus required. The treatment of nervous and muscular affections by means of the continuous and alternate currents, when properly applied in suitable cases, is of the greatest possible advantage. That its use, however, has been overestimated is probable, and it is often used in cases in which it could not be expected to be of service.

The recent advances made in the study of electricity enable us to obtain our supply from many sources. Until a few years ago, primary batteries only were at our disposal, and so great were the difficulties in their use that the best authorities in medicine often despaired of obtaining a reliable apparatus. Now, however, we have the current produced by motor power and the dynamo, secondary cells; and still more recently transformers, continuous or alternate, have rendered the production of the current as reliable as any source of light or heat at our disposal. For example, the secondary batteries or accumulators, although requiring to be recharged at intervals, being so clean, free from smell, and requiring no lifting of plates, are so convenient and reliable that they bid fair to displace the primary batteries altogether. One great advantage we have in using them is that one can tell beforehand how much electricity remains in a cell, and to that extent we can fully rely upon it. No doubt, attempts have been made to improve the primary batteries; but, if we are to be guided by the tendencies in the arts, the indications are rather against than in favour of the primary cells. At present, although many praiseworthy attempts have been made to improve the latter, it may be said that, where high electromotive force is required in medicine or surgery, Leclanché's cells are used; and, for cautery purposes, bichromate and chromic acid are the most popular.

When we consider the various currents used in surgery, a considerable range is necessary in the number of ampères and volts, on account of the difference of resistance which the current will meet in the circuit; for example, in using the cautery we may require twenty ampères and two volts; when lighting a lamp, one ampère of current and five to ten volts, probably; when stimulating muscles, a range of one to twenty milliampères of current will suffice, but we may require an electromotive force as high as thirty or forty volts to overcome the resistance of the tissues. In other words, for medical purposes we may require a high current and low electromotive force, or a low current and high electromotive force. To overcome this the methods at present adopted are, in the former, to arrange the cells in series, and in the latter in parallel, and thereby increase the current; or it may be, instead of a number of cells in parallel, to increase the size of the plates and thereby diminish the internal resistance of the cells. The table exhibited to the members is built up on these principles. In it two circuits are present, one for the cautery and electric light, the other for the constant and interrupted currents. The first circuit is worked by secondary cells, E.P.S. form. The other circuit for constant and alternate currents by means of Leclanché cells.

By whatever method we endeavour to get the various currents from cell batteries, it means great expense, rearrangement of cells before using, and apparatus not easily carried about; so the question naturally arises—Could not batteries be replaced entirely by some such arrangement as the motor, dynamo, or transformer? That this can be done is almost certain, and a cheap, portable arrangement of this kind, suitable for all medical purposes and thoroughly reliable, will, in the future, be obtained most probably in the form of the transformer. By this means batteries, as a source of electricity in surgery, will be reduced to a minimum, if not entirely done away with.

* Read in the Section of Laryngology and Rhinology at the Annual Meeting of the British Medical Association, held in Glasgow, August, 1888.

The Electric Light in Cornwall.—The electric light is being gradually taken up by the tradesmen of St. Austell.

CITY NOTES, REPORTS, MEETINGS, &c.

The Great Northern Telegraph Company.

AT the recent annual meeting of the Great Northern Telegraph Company in Copenhagen, the chairman, Herr Tietgen, Danish Privy Councillor, gave some interesting particulars of the past and present working of this company.

In 1887 the cables of the company were only broken four times in Europe and seven times in Asia, all being soon repaired by their steamers, except one, viz, the breaking of the cable at Vladivostock, in Eastern Siberia, which was repaired by the company's resident manager, Herr Sonne, with the primitive means at his disposal, a highly creditable feat.

Referring to the ever-burning question among telegraph engineers—How long can a submarine cable last? the chairman tendered the experiences of the company, remarking, however, that this would greatly depend on external conditions, as, for instance, the nature of the sea bottom, the quality of manufacture, &c. The oldest cable in the service of the company was that between Denmark and Norway, which had now been in constant use for 22 years, but which really was a great deal older, as it was bought second-hand. However, very little of the old cable could now be said to remain, 69 miles out of its length—85 miles—having been renewed from time to time. Next came the Anglo-Danish cable, which was laid new in 1868, and was thus 16 years old. Its condition was on the whole satisfactory, although it has often to be repaired on the English coast through being damaged by trawling. The Scoto-Norwegian, Swedish-Russian, and Danish cables were also in good condition. In Eastern Asia, too, the cables of the company were in a fairly good state, although the latter have had to be strengthened a good deal. All the rest of the company's cables were in a first rate state, including the Franco-Danish one of 1873, and which at first caused great anxiety by its weakness in certain places. In fact, the experiences of the company went to show that the core of a cable, *i.e.*, the copper wires with their insulated coating of India-rubber or caut-chink, was practically indestructible when remaining in complete rest at the bottom of the sea; but this was far from being the case with the armature, even under the most favourable conditions. Still, careful workmanship and selection of the iron wires might make even the latter outlive the youngest person present. He fully commended the device adopted recently in the deep-lying trans-Atlantic cables of coating each steel wire with India-rubber.

Turning to the chief event of the year in the history of the company—viz., the conclusion of a telegraphic convention with China—the speaker gave some interesting particulars. Having, in conjunction with their ally in China, the Eastern Extension Company, despatched agents to negotiate with the famous Viceroy, Li-Hung-Chang, at Tjentsin, on this point, this personage referred them to the director of Chinese telegraphs at Chefoo; and thither the former proceeded. Simultaneously he, the chairman, went to St. Petersburg in order to obtain the support of the Russian Government at Pekin, which was much interested in the matter, with the same result which had always been his good fortune to meet with in that quarter—namely, that the Russian Government gave its representative in the Chinese capital instructions to give the company every support in his power. Nevertheless, the whole of last summer went by in negotiating, the Chinese desiring at all costs to cancel the convention of 1881. However, at last a convention was signed by both parties, but hardly had this much been accomplished before orders came from Pekin to revoke the agreement, and now lengthy negotiations again ensued, the Chinese Government making several unreasonable stipulations. These ended, chiefly through the pressure caused by the Russian Government, in the signing of the so-called Chefoo Convention on August 10th, 1887, although the terms were very unfavourable to the company. This convention was immediately sent in to the Tsung-li-Yamen at Pekin, the Chinese Foreign Office, for ratification; but, although it had been in the hands of this body for nine months, it had not yet been ratified, and might, in point of fact, be rejected—an uncertainty due to the rivalry between the Viceroy, Li-Hung-Chang, and the Marquess Tseng, the late Ambassador in London, in the Foreign Council. Therefore, in spite of all efforts, the company on this point stood practically where they were before.

The speaker then proceeded to refer to the criticisms which had appeared in Chinese and European journals on this convention, which had even prompted the Chambers of Commerce of Shanghai and Hong-Kong to protest against its conclusion, although neither body had ever seen a clause of it. It had been asserted that the company had paid a bribe of 100,000 taels (£30,000) to the Chinese Government for the concession, and that other sums had been paid to private individuals, but there was not a shadow of truth in either statement; in fact, the "boot ought to be on the other leg," as the company was very reluctant, and the Chinese very eager, to accept the convention. The case was this. Submarine cables had hitherto conveyed all the telegraphic traffic of China with abroad, but the time was approaching when the Chinese land lines would become directly connected with those of neighbouring states, and thereby new telegraphic outlets be established which the convention of 1881 provided against. The arrangement between the company and the Chinese Government was simply this: that instead of opposing each other they should in future co-operate by adjusting each other's charges, and thereby divide the profits of the business, so that the charges on the telegrams passing to and from the cities where the cables are landed became the earnings of the cable companies, and those between other towns of the Chinese Government. Thus the public could choose whichever route they preferred. It had cost the administrators much anxiety to agree to this arrangement, which would at once deprive the company of the great revenue now derived from the traffic between towns not touched by their cables and abroad, even if the public—which was probable—would continue to prefer the submarine routes. Moreover, it will preclude the company from sharing the increase in business which was sure to ensue from the interior of China, as that country was being opened up to European enterprise. But in exchange for these sacrifices the company would obtain the guarantee of a more reliable and steady Chinese business, although, perhaps, less profitable. On the other hand, the Chinese Government receives at once a larger increase of revenue than could possibly be the case under the old system; but then it renounces part of the business between the cable towns, which no doubt would be the predominating for some time to come. Therefore it was untrue, as had been stated in the Press, that the company attempted to prevent the construction of Chinese land cables over the frontier. It was, in fact, a matter of indifference to the company how many were laid. It was evident, from the support received by the British and Russian Embassies at Pekin, that the arrangement was a fair and just one, each of these Governments having opposite interests to serve. The company had received the assistance of every legation in the Chinese capital, that of Germany even censuring the Hong Kong and Shanghai Chambers of Commerce for an interference which was unjustifiable. What the issue of the deliberations of the Tsung-li-Jamen would be it was impossible to foretell, but should the convention be ratified the shareholders would have to be prepared for an immediate decrease of revenue, and what the result would be in case of rejection it was less possible still to say. However, the company was, through following the grand policy of "laying by for a rainy day," in a position to weather any storms.

Turning to the telegraphic enterprise of the Chinese, Herr Tietgen stated that much less activity had been displayed by them in 1887 than during preceding years. The northern telegraph line referred to last year had certainly been extended to the Russian frontier by two branch lines, and the Yunnan line *viâ* Hankow and southwards, extended to the frontier of Tonkin. It is particularly these undertakings which caused the negotiations referred to. Moveover, China had laid her first submarine telegraph cable between the Island of Formosa and Foochow, whilst the Pescadores Islands had also been connected with Formosa. The cable with Corea, referred to in previous years, had not yet been laid, the material having gone down in the Red Sea with the steamer conveying it.

The Chairman further mentioned that last year he had announced that the Russian Government had introduced the Wheatstone system on the line between St. Petersburg and Irkutsk by the aid of Danish operators, and now this arrangement had been completed by also engaging Danes for the regions east of Irkutsk. The latter had probably by that time reached their destination.

The financial aspects of the company were as follows. The gross receipts for the year amounted to £310,000, of which £250,000 were for telegrams. The total expenditure, including repairs and maintenance of plant, was £96,500, leaving a profit of £213,500. Of this sum £55,000 were transferred to the reserve fund, which then amonnted to £525,000. The dividend declared for the year was 7½ per cent.

The Direct Spanish Telegraph Company, Limited.

THE report and accounts of the directors for the half-year ended 30th June, states that the accounts for the half-year ended 30th June, 1888, show, after providing for debenture interest, a balance to the credit of profit and loss of £5,529 19s. 4d. The traffic receipts show an increase of £851 2s. 6d. as compared with the corresponding half-year of 1887.

Both the company's cables and the land-lines in connection with them have continued in good working order throughout the half-year. The special wire erected by the Spanish Government between Bilbao and Madrid, referred to in the last report, has now been put at the company's disposal for the exclusive use of their Bilbao cable traffic.

In consequence of the fleets of several nations assembling outside Barcelona, on the occasion of the opening of the Universal Exhibition in that city by the Queen of Spain in May last, it was necessary to take special precautions for the protection of the shore end of the cable. The cost thus incurred, as well as that of the new cable house at Barcelona, is being charged to revenue.

After putting the sum of £2,500 of the balance of profit and loss to the reserve fund, which now amounts to £11,028 5s. 7d., there remains £3,029 19s. 4d. Out of this amount the directors recommend the payment of the dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend at the rate of 5 per cent. per annum (free of income tax) upon the ordinary shares, carrying forward £274 7s. 4d. to next account.

The Eastern Extension, Australasia, and China Telegraph Company, Limited.—The accounts for the half year ended June 30th last show, subject to audit, a balance of profit of £79,153, after the payment of the interim dividend for the first quarter and charging the cost of the completion of the Singapore-Saigon cable renewal, amounting to £15,401. The directors have declared a dividend for the quarter ended June 30th of 2s. 6d. per

share, free of income tax, payable on October 16th prox., and have decided to carry the balance of £47,903 forward to the next account.

Telephone Company of Austria, Limited. — The directors have declared an interim dividend at the rate of 6 per cent. per annum on the preference shares of the company for the six months ending on the 30th inst.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending September 21st, 1888, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,065.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ending September 21st amounted to £4,956.

NEW PATENTS—1888.

13342. "Improvements in commutator brushes or equivalents therefor." J. V. SHERRIN. Dated September 15.

13402. "Improvements in the construction of secondary batteries." S. A. VARLEY. Dated September 17.

13422. "Improvements in fire-damp indicators for mines." J. PITKIN. Dated September 17.

13473. "Improvements in and connected with electric primary batteries and motors, and in their application to launches and other vehicles." J. SHERRIN and J. V. SHERRIN. Dated September 18.

13488. "Improvements relating to push button telephones." M. C. GREENHILL. Dated September 18.

13519. "An improved electric-motor." F. TEAGUE. Dated September 19.

13529. "Improvements in electric meters." A. RECKENZAUN. Dated September 19. (*Complete.*)

13530. "A combination switch holder for incandescent lamps." C. E. S. GILBERT. Dated September 19.

13584. "Improvements in electrical tell-tales." E. MEYER. Dated September 20. (*Complete.*)

13598. "Improvements in electric-motors." R. R. HUTCHINSON. Dated September 20.

13615. "Improvements in or relating to cases for electrical batteries or cells." G. B. SATTERLEE. Dated September 20.

13621. "Improvements in electric meters." S. Z. DE FERRANTI." Dated September 20.

13622. "Improvements relating to meters for the measurement of alternating currents of electricity." S. Z. DE FERRANTI. Dated September 20.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1888.

1851A. "A sound conveying tube for telephones, graphophones, and like instruments." J. Y. JOHNSON. (Communicated from abroad by the Volta Graphophone Company of America.) Dated February 7. 8d. Claims:—1. In a sound recording or transmitting device, the combination with a diaphragm responsive to sonorous vibrations of a disc forming an air chamber in front of the said diaphragm, the said disc having a number of apertures arranged in series dividing the diaphragm into rings of equal width, the said apertures being connected with a common tube or mouth piece, substantially as described and illustrated. 2. The combination with a diaphragm and a sound conveying tube of a conical deflector having its apex in the axis of said tube, an outer casing and one or more perforated discs interposed between said casing and diaphragm, the perforations of said discs being so disposed as to form sound passages all of the same length, but leading to different points on the surface of the diaphragm, substantially as described.

2308. "Improvements relating to dynamo-electric machines." C. COERPER. Dated February 15. 4d. Claim:—In the construction of generators of electricity the arrangement in which the magnetic field and armature are rotated in opposite directions, namely, by means of two connecting rods such as are generally used in machine construction, and which are connected either with the piston rod of a cylinder, or with two or more piston rods of two or more cylinders.

3246. "Improved electrical lamp and projector and method of applying same for maritime and other purposes." F. WALKER. Dated March 2. 8d. The object of this invention is the production of an electrical lamp enclosed in a suitably mounted lantern or projector for facilitating the night navigation of narrow waterways, such as ship canals; as also for signalling purposes, and as a search light generally, and which may also be applicable for use on board police, admiralty, and other launches and boats, mounted in any suitable manner otherwise than upon a raft as set forth. The claims are 7 in number.

3303. "Improved apparatus for registering the consumption of electric energy." H. H. LEIGH. (Communicated from abroad by J. L. Clerc, of Paris.) Dated March 3. 8d. Claims:—1. The use of a single clock adapted at given times and by means of a special rheostat to return indicating apparatus to zero without shocks, and to transmit a motion, proportional to the indication, to a register provided with a scale in each apparatus; substantially as described with reference to the figures. 2. The combination of relay, arm, and spring, by means of which electric energy can be registered by different apparatus successively, according to the intensity of the current, substantially as described.

3678. "Improvements in and relating to electrical signalling on railways and in apparatus therefor." W. G. OLPHERTS. Dated March 9. 8d. The improvements according to the invention are devised for the use of platelayers, engineers and others working on lines of railways, as also for signalling from a distance at level crossings, the approach of a train in either direction. The claims are 8 in number.

4277. "Improvements in electro-mechanical movements." A. J. BOULT. (A communication from J. F. McLaughlin, of Philadelphia.) Dated March 20. 8d. Relates to a new and improved electro-mechanical movement, and has for its object to utilise the attractive power of electro-magnets to impart a reciprocating or vibratory motion to a fulcrumed lever, which latter motion may be transmitted into a rotary or other movement as may be desired. The claims are 3 in number.

4524. "Improvements in portable galvanic batteries." W. J. S. BARBER-STARKEY. Dated March 24. 8d. The external or containing part of the cell is preferably cylindrical, and is provided at or about the middle of its interior with a diaphragm or piston, to the underside of which the plates or electrodes are secured. The cell may be made reversible or non-reversible; in the former case the diaphragm or piston is moved only when it is required to clean the cell or renew the electrodes. On reversing the battery the electrolyte flows through the diaphragm or piston or through side passages, into that part of the cell not occupied by the electrodes. When it is desired to avoid the reversal of the cell, a rod or rods or a cord or cords is or are attached to the diaphragm or piston, by means of which it may be drawn upwards in the cylinder until the electrodes are out of contact with the electrolyte. The cell is reversed when required by means of two trunnions formed upon or secured to the cell, and bearing in a handle or support. The claims are 4 in number.

4673. "Improvements in dynamo-electric machines and in regulating and measuring apparatus for use with same." P. M. JUSTICE. (A communication from abroad by C. Heisler, of America.) Dated March 27. 1s. 1d. The claims in this specification are 17 in number.

4929. "Improvements in magneto-electric generators." W. GILLETT and G. HASELTINE. Dated April 3. 6d. Claims:—1. In a magneto-electric generator an armature of ring form, provided with segmental projections, substantially as set forth. 2. In a magneto-electric generator a permanent magnet with coils of wire wound upon its extremities, in combination with an armature made in ring form and provided with segmental projections, substantially as set forth. 3. In a magneto-electric generator the combination of an armature provided with segmental projections, cross-bar, permanent magnet, with coils of wire constructed to revolve the insulated wire and spring, substantially as set forth.

4964. "Improvements in apparatus for transforming electric currents." A. J. BOULT. (A communication from Dr. Stefan Doubrava, of Brünn.) Dated April 3. 6d. Claim:—A transformer for electric currents consisting of two condensers of unequal surface, the condenser having the smaller surface being charged by an electric generator having a high potential and discharged into the circuit through a second condenser having a larger surface whereby the original potential is lowered, substantially as described.

5362. "Improvements in arc lamps." J. H. HOLMES. Dated April 11. 8d. Claims: In an arc lamp:—1. A feeding device, comprising a slipper block or friction pawl and a curved spring, the arrangement being such that the spring can be caused to become less curved and more curved alternately, thereby moving the slipper block or pawl forward and backward, substantially in the manner described, so as to feed the electrode. 2. The combination with the feeding device, comprising a slipper block or friction pawl and a curved spring, as referred to in claim 1, of an electro-magnet, and a make-and-break for operating the said slipper block or pawl, substantially as described, for the purpose specified.

5713. "Improvements in electric elevators." J. K. HALLOCK and G. C. BLICKENSDERFER. Dated April 17. 8d. Has reference particularly to a fixed screw shaft or column, a revolving nut or gear engaging with the screw shaft, an elevator car or cage suspended from or supported by said nut or gear, and an electric motor on the cage for rotating said nut or gear in reverse directions, for raising or lowering the car or cage. The claims are 18 in number.

5913. "Improvements in electric telegraph, telephone, and electric light insulators." A. W. HEAVISIDE. Dated April 20. 6d. Claims:—1. The combination of a cap and wedge in one piece, where the cap is screwed on outside the top of the insulator,

and that portion of the cap which projects from its centre forms the wedge; which by fitting into the centre of the top of the insulator when screwed home, exerts a pressure upon the wire enclosed in its bed. 2. The combination of a cap and wedge in one piece, where the cap is screwed on inside the top of the insulator, and in being screwed home exerts a pressure upon the wire enclosed in its bed. 3. The use of an elastic bed at the point of support of the wire, in which bed the wire rests when in position in the bottom of the slot or groove.

6237. "Improvements in jars or cells for primary or secondary electric batteries." A. MILLAR. Dated April 27. 6d. Claims:—1. A jar or cell for a primary or secondary battery having a circular mouth on which is formed a screw thread or its equivalent, whereto a screw ring or cap is fitted and adapted to hold down or retain the cover carrying the electrodes of the battery, substantially as described. 2. The combination with a jar or cell having a screw thread formed on its mouth of a cover, and a screwed ring or cap adapted to fit over said mouth and cover to retain the latter in place, substantially as described.

6416. "Improvements in galvanic elements." L. HOPPE and G. HOPPE. Dated May 1. 4d. Claim:—The application of chemical dung dissolved in water (guano, phosphoric lime, sulphate of ammonia, hyperphosphate of ammonia, bone dust, animal excrement, and saltpetre of Chili) for galvanic elements.

6481. "Improvements relating to the electrical transmission of power and to apparatus therefor." H. H. LAKE. (Communicated from abroad by N. Tesla, of New York.) Dated May 1. 8d. A motor is employed in which there are two or more independent energising circuits through which are passed alternating currents, which effect a progressive shifting of the magnetism or of the "lines of force" which, in accordance with well known theories, produces the action of the motor. The claims are 8 in number.

6502. "Improvements relating to the generation and distribution of electric currents and to apparatus therefor." H. H. LAKE. (Communicated from abroad by N. Tesla, of New York.) Dated May 1. 8d. Relates to those systems of electrical distribution in which a current from a single source of supply in a main or transmitting circuit, is caused to induce, by means of suitable induction coils, a current or currents in an independent working circuit or circuits. The main objects of the invention are the same as have heretofore been obtained by the use of these systems, viz., to divide the current from a single source whereby a number of lamps, motors, or other translating devices may be independently controlled and operated by the same source of current, and in some cases to reduce a current of high potential in the main circuit to one of greater quantity and lower potential in the independent consumption circuit or circuits. The claims are 4 in number.

7536. "Improvements in galvanic batteries." B. WILLCOX. (Communicated from abroad by T. P. Whittier, of America.) Dated May 22. 4d. Claim:—An excitant for galvanic batteries composed essentially of a solution of the residual salts from natural brine, substantially as described.

CORRESPONDENCE.

Electrical Distribution.

I have read with much interest the description of the Edmunds system of distribution which is published in your issue of 14th, but regret to notice that Mr. Edmunds has exemplified his arrangements rather by contrasting them with the arrangements at Colchester in the attempt which was made as long ago as the year 1884. Although not personally responsible for the Colchester system, which was then known as the "B.T.K." system, I should like to correct a few of the more glaring misstatements which I find in your account of Mr. Edmunds's paper.

In the first place, duplicate sets of batteries were *not* employed at Colchester, but the whole battery, which was capable of maintaining the maximum number of lights for eight or nine hours, was charged in *two halves*. It will be noticed by the attentive reader that for a 48 volt circuit, Mr. Edmunds requires 32 cells, whereas by the B.T.K. system at Colchester or any modifications thereof only 26 cells would be needed. This is evidently rather important, as it necessitates the expenditure of 20 per cent. more capital on the item of batteries.

Mr. Edmunds objects, on the score of failure at Colchester, to placing sets of cells in parallel when one set has been freshly charged and the other set partially exhausted, but he appears to ignore the fact that he himself does the same thing if his description and illustration at fig. 4 are correct, where battery A is placed in parallel with battery B.

The statement that the Colchester system was ultimately abandoned is premature, as not only has the system not been abandoned, but it has now been perfected, far beyond anything that Mr. Edmunds seems to have attempted. The apparatus as used at Colchester was imperfect, but the system, as such, is likely to prove an absolute success.

It is further stated that by means of the Edmunds distributor a constant potential is maintained on the local circuit. Now does this mean that the storage cells in use give 2·25 volts per cell while discharging, or, what is more likely to be true, does it assume that the electromotive force of the freshly-charged cells is brought down to the normal of those in the discharge circuit, because of the rush of current from the freshly-charged cells as at A to the partially exhausted cells, B, in fig. 4 of the diagram? As a matter of fact, it will be found that the potential of the discharge circuit at, say, 3 p.m. in the local line of the Edmunds typical installation of 32 cells will be about 54 volts, while at, say, 10 p.m. with the lights all on, it will be from 45 to 47 volts, a difference of about 16 per cent., this difference somewhat contradicting Mr. Edmunds's statement that *the constant potential* at which he can work enables him to use lamps which are very efficient because of never being over-run.

The calculations as to the power required on the two systems under comparison are very wide of the mark, for on the Colchester arrangements the engine power applied to dynamo pulleys is two-thirds the maximum capacity of the battery, such power being sufficient to maintain the battery fully charged and able to sustain the maximum lighting for eight hours, while with the Edmunds distributor, and, presuming the dynamos to be at work for 22 hours per day, the power applied to dynamo pulleys must be equal to about half the lighting capacity of the battery. In addition to the above mentioned difficulties in the way of the Edmunds system, it must be remembered that only three quarters of the current capacity which is generated can be applied to the discharge circuit.

Further, the power required by the Edmunds system for charging the recurring sets of eight cells of his typical installation will average 19·4 volts for 20 hours, because the system necessitates charging one-third more batteries than can be used for discharge, while the power required for charging a battery to do like work on the Colchester system will be 29·9 volts for 9¾ hours, both systems being presumed to work at like current strength. These facts somewhat discount the assertion that the electromotive force required on Edmunds's system is only one-third of that required on the Colchester system.

While appreciating the ingenuity of Mr. Edmunds's apparatus it will serve no good purpose to ignore the utter inadequacy of his methods for actual everyday distribution. The problem is a much more serious one than Mr. Edmunds seems to imagine, and even if he were able to add such regulating apparatus to the discharge circuits as are absolutely necessary, and to make his apparatus work without skilled attention, the use of one-third more battery power than would be required on other systems must certainly prove a fatal objection to the general adoption of such a system in preference to more simple, effective arrangements already at hand.

C. Johnson.

A. G. Bell not the Inventor of the Magneto Telephone.

The importance which is due to the magneto telephone invented by Dr. Cushman in 1851 does not seem to be appreciated by the public at large, and the almost total silence respecting it by the so-called scientific publications here can be attributed solely to the influence which the colossal wealth of the Bell telephone has in this country. In American Notes, published in the *Review* of the 17th August last, there were some com-

ments on the case lately decided against the Cushman invention in favour of the Bell company; and full particulars were promised—which promise I now attempt to fulfil, having received the brief of the defendants, and the judgment of the court, from which I shall collate the *facts* which were established by many unimpeached witnesses and admitted by the judge. The fact was clearly established that "in 1851 Dr. Cushman constructed a device containing magnetic coils through which spoken words could be and were transmitted at short distances." Those words are quoted from the decision of the judge. I take from the judge's decision the following description of the device of Cushman:—"A small box contained two electro-magnets, the lower ends of which were connected by a bar of soft iron, and connected to the middle of the bar was a permanent steel magnet, the upper ends of all these magnets being in the same plane and reaching nearly to the under side of the cover of the box. A small hole was made in the cover of the box directly over the upper end of the permanent magnet, and attached to the under side of this box cover and in close proximity to the upper ends of the magnets was a plate of thin sheet iron interposed between the permanent magnet and the hole in the lid of the box. The wires from these electro-magnets extended to the outside of the box so as to connect them with a transmitting wire and a ground wire."

Will anyone have the audacity to deny that the instrument above described does not constitute a magneto-telephone, capable of transmitting undulatory electrical impulses, and also capable of reproducing the sounds or words spoken which caused the undulatory impulses? With this evidence uncontradicted, will any person (save the Bell monopolists) have the audacity to claim that the magneto-telephone described by Prof. Bell in his patent of 1876, was the first invention of the telephone.

The evidence, uncontradicted, shows that "two of such boxes were attached to an upright board, so that while speaking into the hole of one box, the speaker's ear was near the hole in the other box. Boxes of same construction were placed on a board at a distance of three miles, and words spoken into the hole of one box were heard distinctly at the hole in one of the boxes at the other end of the line." The wire of the telegraph was used to connect the two instruments.

Many witnesses testify as to the use of these boxes at different towns; at one place they were used regularly at a rope walk to give instructions to the workmen.

The judge said "the apparatus described by Cushman is conceded to be identical in principle, construction, mode of operation and result with the Bell device," and as the proof clearly shows they would transmit speech, as admitted by the Court, can it be truthfully said that Cushman did not anticipate Bell in the discovery of a mode of and apparatus for the transmission of speech by means of electricity?" It was established by several witnesses that several capitalists went to hear "the talking boxes," as they were called, with the view of utilising the invention in connection with fire and police alarm systems, but they thought it would not talk loud enough for that purpose; they testified that they heard words and sentences, but faintly.

It is in evidence "that in 1853 W. P. Cushman, brother of Dr. Cushman, lived on a farm six miles west of the town of Racine, and B. T. Blodgett had a shop in Racine. A telegraph line passed by their houses and that of Dr. Cushman. One of these 'talking boxes' was placed in one of the rooms of Dr. Cushman's house, another in Blodgett's shop, and a third in a building on W. P. Cushman's farm, the three boxes were connected with the wire of the telegraph line, and were used when the telegraph line was not used for telegraphic purposes to talk between these three houses; that intelligible orders or requests by articulate words were sent from the farm through these boxes to Dr. Cushman's house for the repair of farm implements and the interchange of the usual social and family enquiries." The judge, while admitting the established facts that Cushman had in 1851 discovered a method and made an apparatus for the transmission of speech, has yet decided that Cushman did not thereby anticipate Bell, and says:—"I think there is nothing shown by the evidence in this case to have been accomplished by these experiments which could not be attributed to the action of a device operating as an *acoustic telephone*, or the ordinary relay telegraph instrument." There is no evidence of the existence of an *acoustic telephone*, sometimes called "*lovers'*" *telephone*, in 1851, or before 1874. The existence of magnets in the Cushman boxes at once negatives the possibility of their operating upon the principle of the acoustic telephone. If Cushman's invention was the simple acoustic telephone instead of an electric telephone, what function was performed or what purpose was served by the presence of the ground wire—as testified to by twenty-two unimpeached witnesses. The judge held that the use of Cushman's device was limited and the result more or less perfect and hence should not be regarded as rising above the plane of abandoned experiments. In the face of the testimony of many witnesses accepted as true by the judge—that Cushman's device was made in 1851—that articulate speech was transmitted by it to a distance of six miles, that the instruments had electro-magnets in them with a thin iron plate in front of end of magnets, that the coils on the magnet were connected by wire to the ground and together by wire six miles long, this *learned!!* and *unbiased* judge!! decided that those instruments were an infringement of Bell's device, invented in 1876. A veritable Dogberry is among us. The case will be appealed to the Supreme Court of the United States, and I do not hesitate to predict that the Cushman invention will be decided to anticipate Bell's.

In England the Cushman invention cannot affect the status of the Bell or Edison patents; but in the United States the establishment of the Cushman invention to have been prior to that of Bell will invalidate Bell's patent of March 7th, 1876.

The Bell people can talk about any action by the Supreme Court on an appeal, because such appeal could not be heard for at least two years, unless the Supreme Court should advance the case. But the case of the U.S. *v.* Bell patent can be tried in January next in Boston, provided the Supreme Court decides that the U.S. Government has a right to bring an action to vacate a patent, which is to be argued on October 9th. On the trial at Boston, then, the Cushman invention will be set up by the Government as anticipating Bell, and I do not think there is any doubt that Bell's patent will be annulled.

As a commercial enterprise the Bell patent has been a success; but I suppose Bell will be shorn of the honours heaped upon him. And Dr. Cushman all the scientific world will proclaim as the *first* inventor of the telephone.

W. C. Barney.

Lightning.

Mr. Varley appeals to me at the end of his article, on page 319 last week, to explain why I suppose lightning to be an alternating discharge.

I think he rather misapprehends the point if he imagines that I assert for lightning anything which I do not assert for a Leyden jar discharge. I have frequently called attention to the fact that lightning is a spark direct between the two coatings of a condenser, viz., the clouds and the earth; and what is true for a condenser spark under these circumstances will be probably true for lightning. Any discharge is necessarily oscillatory unless the resistance of its path is great enough to dissipate the whole of the charge's stored energy at one quarter swing. If the resistance be great enough for that, then indeed the discharge will be dead-beat; but in ordinary cases the resistance is far too small for this, and so the momentum of the discharge current carries it beyond the zero point and effects a reverse charge, which will then rush back again, and so on, several times, usually hundreds

of times. A released pendulum or spring represents the whole thing exactly; there is no mystery about it whatever.

Mr. Varley is a little unfair (unintentionally, of course) in his comments on my experiment with the tinfoil spiral and zigzag, page 317. He says that I admit there are "points requiring further examination." So there are, in the theory, but not in the experiment. The experiment is simple and straightforward enough, and anyone can repeat it. It is not customary to wait till one sees the whole theoretical meaning of an experiment before describing it and deducing a moral from it. I happen to have given the theory of most of my experiments, but I was by no means bound to. It so happens that by help of an observation of Lord Rayleigh's the theory of this experiment also is fairly clear to me now; but that is of no consequence at all. Mr. Varley implies that there were points about the experiment itself with which I was not satisfied, and into which I should have to look more carefully, but that nevertheless I proceeded to argue upon it as if it were perfectly satisfactory; and that in general I am accustomed to fit facts to a preconceived theory. To this tone I have a right to object, and I do object.

With regard to the experiments of Mr. Wimshurst, I wish Mr. Varley had given a reference to them instead of merely saying "in a contemporary." I should then have had the greatest pleasure in looking them up. Those quoted by Mr. Varley are merely confirmatory of mine. Mr. Wimshurst finds, as I found, that all metallic conductors do equally well, and are selected by the flash, one as readily as another, under the impulsive rush circumstances. He also finds, as I found, that a high water resistance inserted in the path of any conductor destroys its efficacy under the same circumstances.

I have no hesitation in saying, on theoretical grounds, that if the experiments were susceptible of great accuracy, the strip conductors would be selected rather more often than the rod; but the difference between rod and strip is too small to be experimentally detected without considerable care.

There are several misprints in your report of my British Association papers last week, some of which it may be worth while to correct. Page 306, in the expression for l_1, $\frac{r_1}{\mu}$ should be $\frac{r_1}{p}$; and in the expression for s_1, $\log \frac{a}{b}$ should be $\log \frac{b}{a}$.

To the words "So velocity of pulse along a wire =" add *for very high frequencies of alternation.*

At bottom of first column of same page, "knots" should be *knobs.*

In the "Abstract," "1,000 million" should be *100 million.*

Top line of second column of page 307, $p\ l$ should be $p\ L'$.

Towards end of same column, "change of $\frac{1}{1000}$" should be *change to* $\frac{1}{1000}$.

Middle of same column, I find sometimes "open" and sometimes "ω" for the word *ohms.* Notwithstanding incipient custom I regard both these abbreviations as equally objectionable.

Oliver J. Lodge.

September 24th, 1888.

Galvanic Belt Quackery.

I have examined one of Harness's three-guinea electropathic belts taken from a patient, and I have failed to get the slightest indication of a current, although I have tested the much-advertised appliance with the most sensitive galvanometer constructed.

Even if the bits of zinc and copper were capable of setting up a current, the construction of the belt is so idiotic, so totally opposed to the laws of electrical science, that each couple would be practically short-circuited, and the physiological action upon the patient would be "*nil.*"

The value of the belt is, in my opinion, equal to five shillings sterling. I have employed electricity for 40 years, and I think that I know how a battery ought to be constructed.

Joseph Clegg, *M.R.C.S. et L.S.A.*

Riviera, Bournemouth,
September 24th, 1881.

I shall feel very glad if you will kindly allow the following, which I have taken from Harness's pamphlet entitled "Electropathy," to appear in your next issue.

Dr. Wilson, in an article lately published, writes:—"I observe that the Medical Battery Company, Limited, whose belt has been *frequently* recommended in *Health* as one of the few genuine electrical appliances which the public may purchase with *safety* and *satisfaction*, have migrated to new and commodious premises at 52, Oxford Street, London, W. In these days of *electrical quackery*, it is highly satisfactory to find that an enterprise for the development of electrical manufacture on a large scale has been successfully projected. The public become necessarily the *gainers* by such enterprise, inasmuch as the aims of a company conducted under the auspices of the Medical Battery Company are those of *perfecting* and extending, by the aid of *capital* and *skilled* labour, the manufacture of electrical appliances as *aids to health* and to the *cure of disease.* I do not doubt the company in question will fully justify, by the excellence of its manufactures, the confidence in its appliances I have hitherto expressed."

Your readers will kindly observe that no mention whatever of the *battery belt* is made in the foregoing. The word *belt* as used above would, I contend, lead any reader to suppose that the belt referred to was the marvellous "electropathic" belt. Why did not Dr. Wilson clearly state that the belt he referred to was the *battery* belt and not the "electropathic," although, in my humble opinion, the former is quite as useless as the latter as an electrical curative agent?

Mr. Lant Carpenter has said and written quite sufficient to convince any sane individual that he looks upon the so-called galvanic belts, magnetic appliances, &c., as utter rubbish.

Dr. Wilson does not deny his connection with Harness. He tries to wriggle out of the hole he is in by saying, What has the ammoniaphone to do with electropathic belts? The ammoniaphone business proves conclusively his connection with the only "eminent electrician" this country has the misfortune to possess.

I can assure Dr. Wilson that I am perfectly capable of understanding "plain English," and also of reading in my own mind the reason for his connection with Messrs. Harness.

If I am successful in exposing electrical quacks—and editors who, for the sake of loaves and fishes, sink so low as to accept their misleading advertisements—I flatter myself that I shall at least deserve the thanks of a few of the British public.

As Dr. Wilson's playful sarcasm does not tend to promote the object in view, I do not consider it necessary to make any comment on the same.

J. Jerritt, *A.S.T.E. & E.*

September 24th, 1888.

Synthetic Study of the Dynamo.

Allow me to point out that the field of force represented in fig. 25 of your issue of September 21st—in which the lines of force are straight throughout, but vary in density from one place to another—is a mechanical impossibility. If a magnetic pole were carried round a rectangular circuit, of which two of the sides, parallel to the lines of force, are situated in regions of different strength, the result would be a perpetual motion.

Rayleigh.